

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
In Cooperation with the Ohio Agricultural Experiment Station

SOIL SURVEY
OF
MUSKINGUM COUNTY, OHIO

BY

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COUNTY SURVEYED

Muskingum County is in the east-central part of Ohio. Zanesville, the county seat, is about 45 miles east of Columbus. The county is approximately rectangular in shape, being about 27 miles long and 25 miles wide. It comprises an area of 664 square miles or 424,960 acres.

In the central part of the county, in an area bounded by the hills south of Muskingum River where it sweeps to the east between Frazier and Duncan Falls, on the east by the range of hills east of Salt Creek, on the north by a line drawn approximately from Norwich to Ellis, and with an open side to the west, there is a basin or region of lower elevation, possibly an old peneplain or other surface feature. This area is marked by a number of old valleys, the largest of which extends in a northwesterly direction and is most noticeable near Perego School, Sonora, and Robertson School.

Muskingum County consists of a plateau, sloping westward. The eastern or highest part is thoroughly and deeply dissected and consists of narrow ridges spreading in a dendritic pattern between the drainage ways. The valleys are narrow and V-shaped, most of them are marked by very narrow ribbons of flood plain, and the valley slopes are steep. On the steeper slopes slumps and slides take place. The ridge tops in many places are uneven in elevation, showing dissection so complete that stream heads from opposite sides have reduced the original elevation. In this part of the county the ridge tops reach an extreme elevation of more than 1,100 feet, and most of them are at least 1,000 feet above sea level. In the southeastern part of the county the elevation ranges from 1,286 feet at High Hill, the highest point, to 660 feet where Muskingum River leaves the county, the lowest point.

The central, western, and northern parts of the county are marked by hilly or rolling relief. Ridges are wide, smooth, and rolling, slopes are gentle, and valleys are wider than is characteristic of the eastern part. Some valleys are rather sharply cut, but on the average they are distinctly more subdued than those in the eastern part of the county. The ridges in this division average from 900 to about 1,000 feet in elevation.



FIGURE 1.—Sketch map showing location of Muskingum County, Ohio

Through its main tributaries, Licking River, and Wills, Wakatomika, Moxahala, Symmes, and Salt Creeks, the drainage waters of the county are carried out by Muskingum River. Streams and branches ramify all parts of the county, and all the uplands are well drained.

Muskingum County was formed in 1804. The early settlers were principally from Virginia, West Virginia, Pennsylvania, New York, and the New England States. Many of them obtained grants of land for military services. The present population, except around Zanesville and in the manufacturing towns and coal-mining districts, consists mainly of descendants of the early settlers. Zanesville was laid out in 1789, and for a short period about 1810 it was the State capital.

The valleys and sections along the main roads are the most thickly settled. The smoother areas in the central, western, and north-western parts are rather uniformly settled, and the hilly section east and northeast from Brush Creek toward Chandlersville is the most sparsely settled part of the county. Many farmhouses have been abandoned in Bluerock, Meigs, and the lower part of Salt Creek Townships.

The population of the county, according to the 1920 census, was 57,980, of which 49 per cent, or 28,411, was classed as rural. The average density of the rural population was 42.8 persons to the square mile. Between 1900 and 1920 the rural population decreased 4.2 per cent, and the urban population increased 24.6 per cent.

Zanesville, the county seat and only city in the county, had a population of 29,569 in 1920. It is the chief trading point for the county and is an important center for coal, oil, gas, and molding sand. It has a wide reputation for its clay products, such as pottery, tile, and brick, and one of its tile works is said to be the largest mosaic-tile plant in the world. Steel mills, bottle factories, and a variety of other manufacturing plants are situated there.

Roseville, in the southern part of the county, has a population of 1,349. This town is the center of a farming community and is an important coal-mining, brick, and pottery center. South Zanesville and Fultonham are important brick and tile-manufacturing points. Philo, 10 miles southeast of Zanesville on Muskingum River, has a very large electric steam-power plant that distributes electric power for many miles over high-tension lines. New Concord, in the extreme eastern part of the county, is the seat of Muskingum College. Frazeyburg, Dresden, and Trinway are farming centers and shipping points in the northern part. Cannelville and Stovertown are coal-mining towns in Brush Creek Township. A number of small trading centers are located in various parts of the county.

Deposits of molding sand in the central part of the county are of considerable importance. Commercial coal mining is important along Muskingum River and the railroads. Small wagon mines are located in the central, northern, and eastern parts of the county, and many farmers devote part of their time during the winter to mining their own coal. Gravel deposits along Licking and Muskingum Rivers afford large quantities of sand and gravel for construction and road-building purposes. The various brick and pot-

tery clays that occur in the county are of very great commercial importance. Oil is produced near Cannelville and Blackrun, and gas occurs in these places and near Otsego. Many farmers have gas for lights and fuel from their own wells.

Transportation facilities are afforded by the Baltimore & Ohio Railroad, the Pennsylvania Railroad, and the Wheeling & Lake Erie Railway systems. An electric railway affords passenger and freight service from Zanesville to Newark and Columbus to residents along Licking River. Bus lines operate on all the improved and through roads radiating from Zanesville. Weekly service by boat to Marietta, Pittsburgh, and Cincinnati is afforded on Muskingum River, which is maintained at a uniform stage by a series of dams from Ellis to its mouth.

The main roads in the county are hard surfaced or graveled and are maintained in good condition during most of the year. United States Highway No. 40, which runs through Zanesville, is one of the most traveled roads in the country, and the tourist trade along that thoroughfare grows in volume annually. A new graveled road has been constructed in the old valley in the northern part of the county along the towpath of the old abandoned canal. Excellent brick, concrete, and tar-bound macadam roads connect Zanesville with Dresden and Trinway, Moxahala Park, Fultonham, and Roseville, Duncan Falls, Brookover, and Adamsville. A concrete road connects Frazesburg via Shannon to the Zanesville-Trinway road. Falls Township in particular has a fine system of gravel roads. A new gravel road connects Zanesville, via Duncan Falls, to McConelsville, in Morgan County, and Marietta, in Washington County. In the southeastern part of the county few roads are kept in good condition, and in the winter practically all roads below Chandlersville are impassable to auto traffic. However, the old Marietta road through Chandlersville and Young Hickory is being rebuilt. Telephone service is available through practically all sections of the county.

Zanesville, New Concord, Philo, and Roseville are the principal local markets for farm products. The principal outside markets are Columbus and Coshocton, Ohio, and Pittsburgh, Pa.

CLIMATE

In general, the climate of Muskingum County is similar to that of southeastern Ohio. The winters are fairly moderate, there being few severe drops in temperature, and the fall of snow is moderate. The snow cover is not always sufficiently uniform throughout the winter to insure successful wheat raising.

The summers are usually warm, and some very hot weather, lasting from a few days to a week, occurs at intervals. The summers are sufficiently long and the precipitation is such as to make conditions ideal for most field crops of the North and also for trucking, where the soil is suitable.

More specifically, there are in Muskingum County some significant variations in climate caused mainly by differences in elevation within the county. For a study of these differences the county may be divided into two divisions, according to elevation, namely, the land which averages about 1,000 feet above sea level and that which

averages about 700 feet. The latter division includes the valleys of Muskingum and Licking Rivers, together with some of the smaller tributary valleys, such as those of Moxahala Creek, Salt Creek, and Wills Creek, and the great valley extending across the northern part of the county. The former division includes most of the remainder of the county.

From the appended data it may be seen that the winter averages about 1° F. colder at the higher elevation, whereas the summers average about the same at both places, although the extreme temperature of both winter and summer occurs at the lower elevation. These data indicate that both the total rainfall and the fall of snow are heavier at the lower level than at the higher. This apparent difference may be owing to differences in the length of the periods of observation.

The average date of the last killing frost is April 27 at the 1,000-foot elevation, as compared with May 1 at the 700-foot elevation, and the average of the first killing frost is October 11 and October 15, respectively, allowing equal average frost-free seasons of 167 days. Thus frosts are apt to occur several days later in the spring at the 700-foot station but also several days later in the fall. The latest reported spring frost is recorded for May 28 at both stations, and the earliest reported fall frost occurred at the 1,000-foot station on September 19, or eight days earlier than the earliest recorded at the 700-foot station.

Tables 1 and 2 show the normal monthly, seasonal, and annual temperature and precipitation at two stations at Philo.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Philo (1)

[Elevation, 1,018 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1900)	Total amount for the wettest year (1907)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	31.8	68	-11	2.63	0.79	2.41	5.5
January.....	30.1	73	-13	2.95	2.03	5.01	8.5
February.....	29.7	72	-20	2.20	2.79	1.00	6.6
Winter.....	30.5	73	-20	7.78	5.61	8.42	20.6
March.....	41.6	85	-4	3.48	2.62	8.53	3.5
April.....	51.4	92	18	2.87	1.42	4.37	1.6
May.....	62.3	93	28	3.54	2.78	3.70	Trace.
Spring.....	51.8	93	-4	9.89	6.82	16.60	5.1
June.....	69.9	100	35	4.02	1.71	5.07	.0
July.....	74.3	101	43	4.33	2.50	11.29	.0
August.....	72.6	100	39	3.46	2.23	2.93	.0
Summer.....	72.3	101	35	11.81	6.44	19.29	.0
September.....	66.8	99	29	2.59	.32	5.61	.0
October.....	55.2	90	22	2.49	1.00	1.18	.4
November.....	42.8	76	9	2.13	2.36	1.51	1.4
Fall.....	54.9	99	9	7.21	3.68	8.30	1.8
Year.....	52.4	101	-20	36.69	22.55	52.61	27.5

TABLE 2.—Normal monthly, seasonal, and annual temperature and precipitation at Philo (2)

[Elevation, 750 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1906)	Total amount for the wettest year (1913)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	32.2	70	-19	3.29	2.89	2.08	5.7
January.....	31.2	74	-27	3.62	3.00	7.85	10.1
February.....	31.1	72	-17	2.51	.84	1.83	6.9
Winter.....	31.5	74	-27	9.42	6.73	11.76	22.7
March.....	43.0	87	-1	4.11	4.51	7.50	3.7
April.....	52.2	91	15	3.38	2.55	2.54	2.3
May.....	62.7	97	26	3.77	1.87	3.36	Trace.
Spring.....	52.6	97	-1	11.26	8.93	13.40	6.0
June.....	69.9	100	35	4.42	3.53	2.80	.0
July.....	74.3	102	41	4.88	3.40	12.64	.0
August.....	72.6	106	40	4.10	3.30	5.28	.0
Summer.....	72.3	106	35	13.40	10.23	20.72	.0
September.....	66.7	96	31	3.12	2.76	2.71	.0
October.....	55.2	90	20	2.97	2.92	3.72	.5
November.....	42.8	78	5	2.12	1.25	3.89	1.9
Fall.....	54.9	96	5	8.21	6.93	10.32	2.4
Year.....	52.8	106	-27	42.29	32.82	56.20	31.1

SOIL SERIES AND TYPES

In mapping soils, they are classified on the basis of their natural characteristics which include color of the surface soil and subsoil, texture (that is, the quantity of sand, silt, and clay present), structure or the arrangement of these materials, consistence (resistance to deformation), drainage, origin, and mode of occurrence. All the soils of common origin, color, and structure are grouped together into series. The series are subdivided, according to the content of sand, silt, and clay, into soil types. Thus we have the Wheeling series of soils, which have a common origin, subdivided into the Wheeling fine sandy loam, Wheeling loam, and Wheeling silt loam soil types, which are the units of soil mapping.

In Muskingum County the soils are separated into 18 soil series, including 24 soil types and 7 phases or variations from the typical, in addition to the miscellaneous classifications of material, rough stony land, and mine pits and mine dumps.

The Muskingum series, which occupies by far the greater part of the county, includes soils having grayish or yellowish-brown surface soils over yellow, friable or moderately stiff subsoils. Within from 18 to 30 inches from the surface the partly weathered parent sandstones and shales occur, and fragments of these rocks are found in many places throughout the surface soil and subsoil. Muskingum silt loam, with a smooth phase and a steep phase, and Muskingum loam are mapped.

The Westmoreland series includes soils having yellowish or light-brown surface layers and yellow, friable or moderately stiff subsoils. These soils resemble the Muskingum soils but are affected by the presence of some material derived from limestones interbedded with the predominant parent shales. This limestone material apparently has been distributed from high-lying outcrops to lower positions by rainwash. Westmoreland silty clay loam, with a steep phase, is mapped.

The Meigs series includes patches of the yellow Muskingum soils occurring in close association with patches of the red Upshur soils. There are, also, included areas where there is mixed soil, or yellow soil with overwash of red or red with overwash of yellow. These conditions are especially well shown on slopes where creep, slump, and slide have mixed the red and yellow soils inseparably. Meigs silty clay loam is mapped.

The Belmont series includes soils comprising a variety of undifferentiated materials, rather than a single definite type. In other words, these soils represent a combination of yellow, brown, and red shale soils, along with yellowish and brown limestone soils, with various mixtures of the materials of these more or less distinct types. Belmont silty clay loam is mapped.

In the Frankstown series are included soils derived principally from a rock formation composed chiefly of chert or flint, varicolored fragments of which are present in abundance on the surface and throughout the soil. The soil is yellowish or pale yellow, and the parent material occurs at a depth ranging from near the surface to 2 feet. In places the parent material crops out. Frankstown gravelly silt loam is mapped.

The Zanesville series includes soils having brown, friable surface soils; somewhat compact, though friable, brown subsurface or upper subsoil layers; and friable, mottled gray and brown subsoils containing some rust-brown iron concretions. Zanesville silt loam, with a shallow phase, occurs in Muskingum County.

The Tilsit soils differ from the Zanesville chiefly in having yellow surface soils. The compact lower subsoil layer is yellow or yellowish brown, mottled with gray, and the substratum is gray, yellow, and orange or reddish yellow and is characterized by the presence of dark-brown soft iron concretions. Tilsit silt loam is mapped.

Hanover silt loam, the only member of the Hanover series mapped, is derived from glacial material. It has a grayish-yellow or brownish-yellow surface soil, a yellowish-brown silty clay subsoil slightly mottled with gray and rust brown, and a lower subsoil layer consisting of mottled olive-drab, gray, and rust-brown glacial till.

The surface layer of the Wheeling soils, to a depth of 4 or 5 inches, is brown. In the virgin soil there is an accumulation of vegetable mold to a depth of 2 or 3 inches. The subsurface layer is yellowish brown and continues to a depth ranging from 6 to 12 inches, depending on the stage of development of the soil. The subsoil is yellowish brown or faintly reddish brown and is heavier than the topsoil. The material beneath the subsoil varies in texture with the various soil types. In the silt loam it remains of about the same texture as the subsoil; in the gravelly loam, sandy loam, and loam members of the series it commonly consists of sands or gravels or mixed sands

and gravels. In Muskingum County, the Wheeling series is represented by the fine sandy loam, loam, and silt loam members.

The Holston series includes the well-drained terrace or second-bottom, water-deposited soils whose origin may be traced to the local upland soils of the Muskingum and Zanesville series. These soils are derived almost entirely from sandstone and shales. They are characterized by light-brown or yellowish-brown surface layers with brown or yellowish-brown subsoils. They are underlain locally by a more or less gravelly substratum. Holston silt loam, with a high-terrace phase, and Holston loam are mapped in the county.

Tyler silt loam is the only member of the Tyler series mapped. The series characteristics are gray or mottled gray and yellow surface soils, and mottled gray, yellow, and rust-brown or ochreous-yellow, very heavy, compact subsoils, passing into less-compact substrata of mottled gray and rust brown. The presence of soft iron accumulations is very characteristic.

A group of soils occupying an intermediate position between the Holston and Tyler soils are classed in the Monongahela series. These soils have yellow or brownish-yellow surface soils grading, at a depth of about 12 or 15 inches, into mottled gray and yellow, compact subsoils, in which the gray color increases with depth and finally becomes predominant. Rust-brown, soft concretions are common. Monongahela silt loam is mapped.

Blago silty clay, the only member of the Blago series mapped, is associated with the Tyler and Monongahela soils. It is characterized by a dark-gray or black surface soil rich in organic matter and a tough, compact, mottled gray, yellow, and rust-brown subsoil.

The Huntington soils occupy the well-drained rich-brown bottoms along streams and receive a large part of their drainage waters from uplands consisting partly of limestone soils. They are generally neutral or only slightly acid. Huntington silt loam, with a high-bottom phase, Huntington silty clay loam, and Huntington fine sandy loam, with a high-bottom phase, are mapped in Muskingum County.

The Pope series includes brown well-drained bottom-land soils along streams. These soils receive most of their drainage from sandstone and shale uplands and are typically acid in reaction. Pope fine sandy loam is mapped.

In the Atkins series are included the poorly drained, mottled gray and rust-brown bottom-land soils derived from sandstone and shale upland soils. Atkins silt loam is mapped.

The Philo soils, with respect to drainage, occupy a position intermediate between the Pope and the Atkins. These soils are characterized by light-brown or grayish-brown surface soils and mottled brown and gray subsoils. Philo silt loam is mapped in the county.

The Moshannon series includes well-drained bottom-land soils of a reddish-brown or Indian-red shade, owing to the presence of wash from the similarly colored red soils of the Meigs and Belmont series. Moshannon silt loam is mapped.

Rough stony land, and mine pits and mine dumps are two miscellaneous classifications of nonagricultural material mapped.

The soils are described as they are found under average moisture conditions in the field.

In the following pages of this report the soils are described in full and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in Table 3.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in Muskingum County, Ohio*

Type of soil	Acre	Per cent	Type of soil	Acre	Per cent
Muskingum silt loam.....	120,256	50.9	Holston loam.....	2,432	0.6
Steep phase.....	92,096		Monongahela silt loam.....	6,272	1.5
Smooth phase.....	3,712		Tyler silt loam.....	4,352	1.0
Muskingum loam.....	18,624	4.4	Blago silty clay.....	960	.2
Tilist silt loam.....	640	.1	Huntington silt loam.....	8,192	2.4
Zanesville silt loam.....	24,000	10.3	High-bottom phase.....	2,176	
Shallow phase.....	19,840		Huntington silty clay loam.....	960	.2
Frankstown gravelly silt loam.....	1,088	.2	Huntington fine sandy loam.....	5,376	2.1
Meigs silty clay loam.....	14,848	3.5	High-bottom phase.....	3,392	
Westmoreland silty clay loam.....	16,896	6.6	Moshannon silt loam.....	1,152	.3
Steep phase.....	11,072		Pope fine sandy loam.....	256	.1
Belmont silty clay loam.....	9,280	2.2	Philo silt loam.....	8,640	2.0
Hanover silt loam.....	384	.1	Atkins silt loam.....	6,848	1.6
Wheeling fine sandy loam.....	5,312	1.3	Rough stony land.....	8,960	2.1
Wheeling loam.....	2,432	.6	Mine pits and mine dumps.....	768	.2
Wheeling silt loam.....	3,200	.7			
Holston silt loam.....	9,728	4.8	Total.....	424,960	-----
High-terrace phase.....	10,816				

MUSKINGUM SILT LOAM

Over virgin Muskingum silt loam, as seen in forested areas, is a covering, about one-half inch thick, of dark grayish-brown, partly decomposed organic matter composed of leaves, twigs, and roots. Beneath this is light brownish-yellow or yellow silty clay loam. Below a depth of 12 inches, the material is mixed with varying quantities of small gray or light-yellow sandstone and shale fragments. Below a depth of about 30 or 36 inches is the parent rock, which occurs in various stages of decomposition ranging from loose rotten rock to hard, slightly changed rock. In cultivated fields grayish-brown or yellowish-brown silt loam from 5 to 7 inches thick grades beneath into the yellow subsoil present in virgin areas. Here and there fragments of gray sandstone or shale occur in the surface soil or subsoil.

Included with this soil, as mapped, are small areas of Muskingum shale loam. Such areas consist of a mass of partly disintegrated yellow, greenish, and gray shale fragments with a small quantity of Muskingum loam or Muskingum silt loam grading at a depth of about 4 or 6 inches into the parent shales. This variation occurs on knobs north of Ruraldale, on ridges and knobs east, south, and southwest of Cannelville, and on ridges about three-fourths mile southwest of Marquand Mill. Near areas of Frankstown gravelly silt loam, Muskingum silt loam is strewn with irregular-shaped fragments of flint. Patches of this variation occur widely scattered in a band extending eastward from Flint Ridge School toward Sonora, the largest areas occurring north and northeast of Sonora and about 1 mile north of Bridgeville. The chert fragments occur at the outcrop of the chert-bearing formation, and the fragments are surpris-

ingly light in weight. This variation is more brownish or buff colored than typical. In the vicinity of areas of Zanesville silt loam, and especially near Bloomfield and Fultonham, the surface soil, to a depth ranging from 6 to 10 inches, is brown, velvety silt loam very much like Zanesville silt loam but the yellow subsoil contains partly weathered clay and fragments of shale. In other places, small pockets of loam, which occur just under the brow of hills, on small knobs, or narrow shoulders where sandstone formations crop out, are included in mapping. In a few places, such as near Poverty Run north of Johnson School, a thin limestone outcrops on the slopes. The influence of such limestone is too limited, however, to produce an appreciable acreage of Westmoreland soils.

Muskingum silt loam occurs very widely throughout the county. It is especially well developed in Hopewell, Springfield, Newton, and Brush Creek Townships in the western and southern parts of the county. Other important areas are mapped in Jackson, Cass, and Muskingum Townships in the northern and western parts. The soil occupies smoothly rolling or somewhat hilly ridges and upper slopes and shoulders. The basis of separation between this soil and its steep phase is the relief.

This soil is uniformly well drained, owing to its favorable relief and structure. However, some small, seepy patches along the outcrop of gray fire clays and shales, had they been of greater extent, would have been mapped as Lickdale silt loam. Where Muskingum silt loam occurs on slopes, erosion and gullying are apt to follow too frequent planting to intertilled crops.

Muskingum silt loam is so extensive that it is one of the important agricultural soils of the county. About 75 per cent of it is cleared and about 20 per cent is farmed, the remainder being used for pasture. Practically all the cleared land has, at one time or another, been farmed, but insufficient manure and little or no commercial fertilizer were applied and yields decreased to such an extent as to be unprofitable. In addition, some fields became gullied and were allowed to lie idle or were used for pasture for sheep and cattle. The timbered areas support a growth of various oaks, maple, some chestnut, walnut, elm, beech, hickory, maple, and ash.

Corn, wheat, and hay are the principal crops grown on this soil. The hay is usually mixed timothy and clover. Along the main roads and near Zanesville, dairying is carried on to some extent. Oats, potatoes, and soybeans are of less importance, and some fruit, including apples and peaches, is grown. Raspberries, blackberries, and strawberries are of minor importance.

Corn yields from 25 to 35 bushels to the acre under the average farming methods, although lower yields are common where insufficient manure and commercial fertilizer are applied. Wheat yields 12 or 15 bushels to the acre but gives higher yields with fertilization. Yields of hay average about $1\frac{1}{2}$ tons to the acre but were much less in 1925 during the progress of this survey, owing to an unseasonable dry period in June and July. The pastures support a growth of Canada bluegrass, redbud, a little timothy, poverty grass, and tickle grass, with broom sedge, sumac, blackberries, and sassafras bushes. After long-continued use for pasture, with no addition

of plant food either in the form of fertilizers or lime, the vegetation becomes mainly a mixture of poverty grass, broom sedge, and briars.

In general, this soil is plowed and cultivated without difficulty. Corn is an important crop on the smoother areas. After the corn is harvested the land is disked and planted to wheat and timothy. Clover is sometimes seeded the following spring. Sometimes oats precedes wheat. The land is allowed to remain in hay for two or three seasons, unless a poor catch is obtained or weeds become so numerous as to injure the quality of the hay.

Superphosphate (acid phosphate) is the principal fertilizer used. It is generally applied at the rate of about 200 pounds to the acre on the wheat and in about the same or slightly smaller quantities on the corn. Lime is used by some farmers.

Plans for improving Muskingum silt loam should include the use of about 1 or 1½ tons of crushed limestone or from 1 to 1½ tons of hydrated or burned lime to the acre every four or five years. Alfalfa has been grown successfully following applications of lime and phosphates. The use of larger quantities of superphosphate with the lime will insure a better clover catch, that will in turn improve crop yields. The use of lime and phosphoric acid is of special value in improving pastures, as is shown in the remarkable results of field demonstrations conducted in this and adjoining counties. In this instance between 1 and 2 tons of limestone and 400 pounds of superphosphate to the acre were applied. White clover began to appear very quickly, and as the supply of nitrogen in the soil was built up bluegrass appeared. All this change of vegetation was produced without any seed being applied. To maintain such a permanent pasture about 400 pounds of superphosphate every 5 or 6 years and a ton of limestone to the acre every 8 or 10 years should be applied. The growing of soybeans for hay and soil improvement is becoming more widespread and should be extended even more, as they are an excellent substitute or emergency crop in case of clover failure.

Muskingum silt loam, smooth phase.—The smooth phase of Muskingum silt loam differs from the typical soil principally in having a smooth, gently rolling, or undulating relief that allows the use of tractors and power machinery in the farm operations. The depth to rock is in most places greater and the soil is somewhat browner than in typical areas. This soil, to a depth of 6 or 8 inches, consists of light-brown or yellowish-brown silt loam grading into brownish-yellow rather compact silty clay loam. The parent sandstones and shales occur at a depth between 24 and 30 inches. Some fragments of sandstones and shales are seen in places through the soil, although they are less numerous than in the typical soil. This smooth soil is noticeably more deeply and thoroughly weathered than the typical. In places it is browner and resembles the upper part of Zanesville silt loam, although it has a yellowish-brown tinge as compared with the brown or buff of the latter soil.

This phase of Muskingum silt loam is not extensive but is best developed in the western part of the county, south of Coaldale and Gratiot, west and south of Fultonham, and near Yelptown School. It occupies broad ridge tops and smooth, gently rolling crests and upper slopes. It is well drained.

All this soil is cleared and farmed. Crops and cultural methods are similar to those described for the typical soil, but yields are somewhat higher on this phase.

This soil is prized by the farmers because of its favorable relief. Methods of improvement suggested for typical Muskingum silt loam are applicable also to this phase of soil.

Muskingum silt loam, steep phase.—Muskingum silt loam, steep phase, as its name indicates, includes the hillier and steeper parts of the Muskingum silt loam. Areas are unsuited to farming and, as a whole, are so steep as to be best suited to forestry and use as permanent pasture. Small patches under cultivation probably do not return very much profit, as they entail the use of too much hand labor. Arable areas, too small to be separated on the map, occur at the base of the slopes here and there. Such areas generally include considerable colluvial wash.

Probably 20 per cent of this soil is cleared of its timber growth and is used for pasture. The wooded areas also afford a little pasturage. This is an extensive soil and forms an important local source of timber. The tree growth consists of oaks, maple, ash, beech, and, along the bluffs above Salt Creek, some hemlock. The timber is rapidly being cut, but with some attention to good forest practice this land could be made to produce crops of lumber just as the other kinds of land produce grain and hay crops.

The most extensive developments of this soil occur on the slopes overlooking White Eyes and Wills Creeks, in the northeastern part of the county, southwest from New Concord toward Cannelville, and overlooking the lower part of Muskingum Valley. Other areas are along Jonathan Creek and Kent Run and scattered throughout the hilly parts of the county.

MUSKINGUM LOAM

Muskingum loam has a surface soil of light-brown or yellowish-brown loam from 5 to 7 inches thick. This grades into yellowish-brown, rather compact, heavy loam containing some fragments of sandstone. Below a depth varying from 18 to 24 inches is the unweathered sandstone. Small fragments of sandstone and thin sandy shales or shaly sandstones are common on the surface and through the soil. In places the underlying sandstone is within a few inches of the surface, and here and there small outcrops may be seen.

Included with this soil in mapping, particularly near sandstone outcrops, are areas of sandy loam which are locally referred to as sandy land. In Rich Hill Township some included areas are derived largely from the Gilboy sandstone. In such areas yellow or yellowish-brown loam about 6 inches thick grades into incompletely weathered rock continuous to a depth of about 18 inches. On such areas an abundant bluegrass sod is common, in contrast to the more acid-loving grasses characteristic of most of the soil. Near Smith Mill on a flat shoulder or bench the soil, to a depth ranging from 6 to 10 inches, consists of brownish-yellow loam grading into sandy clay rather than the usual heavy loam. At a depth of about 20 inches is a sandstone layer, giving the appearance of a rock-cut terrace. On the surface are numerous subangular sandstone frag-

ments. Other such areas occur near Bridgeville, where Salt Creek crosses United States Highway No. 40. Such areas are possibly superior to the typical soil, owing to their more favorable relief and freedom from large sandstone fragments. About three-eighths mile north of Duncan Falls an included area is evidently an old terrace, at least in part, which has become eroded around the edges and has lost its true terrace identity. This area is very sandy in patches.

This soil is most extensive northeast of Zanesville, between Sonora on the south, Adamsville on the north, and Anderson School on the east. Numerous other areas are scattered over that part of the county north of Adamsville, in the vicinity of High Hill, Kelley Store, Sandy Ridge School, near Pleasant Valley, and scattered over the area west and southwest of Zanesville. Much of the soil in the southwest part of the county occupies ridges and disconnected knobs having an elevation of about 1,000 feet above sea level. Most of the areas do not extend very far down the slopes.

Muskingum loam occupies bumpy, irregular ridges and knolls. Southeast of Adamsville south of South Branch Symmes Creek are some rather steep included areas which would have been separated into a steep phase of the soil, had they been of sufficient extent. Here and there ledges of sandstones outcrop in the slopes or at the break of the hilltops. The relief and rather open structure of this soil cause drainage to be excellent, but there is little erosion. In many places in the northeastern part of the county the soil occupies slopes on which Zanesville silt loam lies on the ridge and upper slopes.

About 25 per cent of this soil, comprising the smoother areas, is farmed. The remainder is used for pasture or remains in woods. The principal crops are corn, wheat, and hay. Corn yields from 20 to 35 bushels and wheat from 12 to 20 bushels to the acre. This is regarded as a better wheat soil than Muskingum silt loam. Occupying ridge tops, as it in so many places does, it is favored as locations for orchards, and several commercial peach and apple orchards are on it near Sandy Ridge School and in the western part of the county, as well as many home orchards. Potatoes and berries, particularly strawberries, are raised commercially in several places. As a whole, the soil does not afford very good pasturage, but near High Hill it produces an excellent bluegrass sod.

Muskingum loam is readily plowed and cultivated and is a somewhat earlier soil than Muskingum silt loam, owing to excellent internal drainage and to the presence of a fairly large percentage of sand. Superphosphate is the principal commercial fertilizer used. It is usually applied at the rate of 150 or 200 pounds to the acre, in the corn drill. Some farmers apply about 250 pounds to the acre with a wheat drill before the corn is planted, and then about 150 pounds in the corn drill with the corn. Some lime is applied, but its use is not general. Complete fertilizers are used on potatoes, bush fruits, and strawberries. For tree fruits, a nitrogen carrier only, such as ammonium sulphate or sodium nitrate, is commonly used.

Leaching proceeds rapidly on this comparatively open-structured soil. The application of manure and lime would improve this condition. The soil is very well suited to fruit raising and berry culture.

TILSIT SILT LOAM

The surface soil of Tilsit silt loam is grayish-brown or yellowish-brown silt loam 5 or 6 inches thick and is underlain by brownish-yellow heavy silt loam or silty clay loam. Small rust-brown, soft iron concretions are noticeable at a depth ranging from 10 to 14 inches. At a depth of about 15 inches, the subsurface material grades into mottled brown and gray, compact silty clay loam containing an abundance of rust-brown concretions. At a depth of about 30 inches the gray becomes predominant, and the quantity of iron concretions increases. Below a depth ranging from 36 to 40 inches mottled gray, yellow, and reddish-yellow silty clay is reached. The abundance of soft, rust-brown iron concretions is especially characteristic of this soil. The substratum, which may occur at a depth between 4 and 6 feet, is variable and consists of gray sandstone and shales in some places and in others of hard gray clay shales. Near areas of the Frankstown soils, the substratum comes to within about 30 inches of the surface.

In patches, the surface soil to a depth of 2 or 3 inches is grayish-brown silt loam passing into pale-yellow silt loam which in turn, at a depth of 13 to 15 inches, grades into yellow or pale-buff silty clay loam. The material becomes compact at a depth of about 18 inches and is mottled yellow and light gray, becoming heavier with depth. At a depth of about 30 inches the gray becomes predominant. Below 36 inches there is mottled gray and pale-yellow silty clay with some light-reddish streaks. The characteristic brown iron concretions are present throughout. In places some flint fragments occur on the surface.

This soil is mapped only in the vicinity of Flint Ridge School in the western part of the county and is not important agriculturally. The largest area is northwest of Wise School. The soil occupies smooth, gently undulating, or slightly rolling areas and is practically all cleared. It occurs in association with Frankstown gravelly silt loam and Muskingum silt loam.

Drainage is only fair, owing to the compactness of the subsoil and substratum, and the soil is rather wet and miry in the spring and hence can not be plowed until late. Some of this soil has been practically abandoned and is used only for pasture. It does not support a very good pasture growth, owing to its lack of available phosphates and to its acidity. Broom sedge is prevalent over the pastures.

Corn does fairly well in moderately dry seasons, and yields as high as 35 bushels to the acre are reported. Owing to the presence of excessive moisture, wheat suffers considerably from winterkilling.

Methods of management are the same as those employed on the Muskingum soils. Superphosphate is the principal fertilizer used. Some lime is applied.

Plowing this soil in narrow lands with water furrows between would help to remove excess water in the spring. Tiling would be beneficial but expensive, because the compact hardpanlike subsoil and substratum would necessitate the tile lines being laid at very close intervals. Initial applications of about 2 or 3 tons of limestone

to the acre and later applications of 1 or 2 tons every four or five years would result in a better hay and clover catch and hence an increase in subsequent crop yields.

ZANESVILLE SILT LOAM

Zanesville silt loam is characterized principally by a brown or buff shade and a distinctly velvety feel as it is rubbed between the thumb and fingers. In wooded areas there is a covering, about one-half inch thick, of decaying vegetable matter under which there is a 4 or 6 inch layer of grayish-brown or light-brown smooth silt loam underlain by rich-brown or buff silt loam of a velvety feel. Below a depth ranging from 15 to 18 inches is somewhat compact material consisting of buff-colored heavy silt loam or light silty clay loam, which at a depth ranging from about 26 to 30 inches is locally streaked slightly with gray. The gray coloring becomes more pronounced at a depth between 36 and 40 inches, where some soft brown iron concretions are present. Below a depth of 38 or 40 inches is brown or buff silt loam, mottled with gray and rust brown. In places this material is very fine sandy loam grading downward into molding sand; in others, very fine-grained sandstone and silty shales or even red clays, such as produce the Upshur and Meigs soils, may occur at a depth ranging from 40 to 80 inches. In the field under average moisture conditions the surface layer of this soil is brown or light-brown silt loam, which is modified by the breaking up of the upper layers and the incorporation of organic matter with the soil.

In places this soil includes areas having a brownish-yellow silt loam surface soil containing considerable very fine sand. Such areas are west and southwest of Zanesville and between Zanesville and Salt Creek to the east. About 1 mile southwest of Perego School are several small, very level patches which have a dull grayish-brown surface soil grading, at a depth of 8 or 10 inches, into yellowish-brown or brown silt loam underlain, at a depth of 20 or 24 inches, by a mottled gray and brown compact layer carrying numerous small soft iron concretions. Below a depth of about 30 inches the material is typical. This phase carries an inferior vegetation of wet acid-land plants and produces only fair corn and wheat. If of larger extent such areas would have been mapped with Tilsit silt loam. In other places the unweathered substratum may occur within 36 inches of the surface. Such areas, had they been of sufficient size, would have been mapped as a shallow phase of this soil.

Zanesville silt loam occurs most extensively in the vicinity of Zanesville, especially to the north, east, and south of that place. The principal areas are within a basin bounded by Salt Creek on the east and extending to Duncan Falls and South Zanesville on the south and to Adamsville and Shannon on the north. Other areas are on the ridges south from Philo toward the Morgan County line, south of Chandlersville, and in the southwest part of the county near White Cottage, Fultonham, and Roseville. The soil occupies smooth, level, or undulating plateaus, ridges, shoulders, and benches or saddles at elevations ranging from about 880 to about 960 feet above sea level. The soil appears to have been largely of water

origin. Practically all the molding-sand pits occur in areas where Zanesville silt loam occupies the surface.

Lack of relief has protected the soil from erosion and gullyng. Locally it is called white-oak land, owing to the prevalence of that variety of tree on virgin areas. Drainage is well established, because of the fact that areas occupy ridge tops and owing to the quantity of very fine sand present.

About 95 per cent of this soil is cleared and farmed. The remainder is included in wood lots and forest areas with other soils. All of the soil has surface features that render it very well suited to farming and the use of all kinds of up-to-date machinery. Timbered areas support the usual hardwood growth of the region, but in places there is an excellent growth of locust trees. In pastures there is a fair stand of bluegrass along with the other native grasses, but in areas kept too long in pasture without fertilizing and liming broom sedge and poverty grass tend to crowd out the bluegrass.

Wheat, corn, and hay are the principal crops produced on this soil. This is considered the best wheat soil in this county and in production compares with Wooster silt loam of northern Ohio. Wheat yields from 16 to 25 bushels to the acre, but as high as 40 bushels to the acre are reported by some of the better farmers during a favorable season. Corn yields from 25 to 40 bushels to the acre and hay from $1\frac{1}{2}$ to 3 tons. The larger yields of hay are obtained after liming. Some oats and rye are grown.

This soil, owing to its smooth relief and freedom from stones and rock fragments, is especially prized by the farmers of the county. It is rather easy to cultivate, owing to the content of very fine sand, is well drained, and is fairly early. Practically all farmers are using fertilizer consisting principally of 16 and 20 per cent superphosphate in applications ranging from 200 to 400 pounds to the acre, although some bone meal and mixed commercial fertilizer analyzing 2-12-2¹ are used.

Zanesville silt loam shows a lime requirement of about 1 or 2 tons of ground limestone to the acre. This initial application and additional applications of about 1 ton to the acre every four or five years would result in improved clover yields and in turn in an increase in organic matter and in better yields of all crops. Excellent alfalfa can be produced by liming and applying superphosphate. Where well located this soil is excellent for tomatoes, potatoes, and apples.

Zanesville silt loam, shallow phase.—The shallow phase of Zanesville silt loam differs from the typical soil in that the substratum of sandstone and partly weathered shales, such as commonly give rise to the Muskingum soils, occurs between depths of 24 and 30 inches below the surface. This soil consists of rich-brown silt loam from 6 to 10 inches thick, grading into brown heavy silt loam or silty clay loam. Fragments of sandstone may be found on the surface and in the subsoil, and on slopes narrow bands of outcrops of shales and sandstones are included in a few places where such areas were too small to be separated into Muskingum silt loam. Patches of Muskingum silt loam, too small to be separated, are also included along narrow drainage ways. North and east of Jackson School are included patches in which thin beds of red clay occur in the lower

¹ Percentages, respectively, of nitrogen, phosphoric acid, and potash.

part of the subsoil. In the vicinity of Milligan School the upper part of the subsoil is browner and heavier than in the typical soil.

This phase of soil occurs in the same general region as typical Zanesville silt loam and is best developed east of Zanesville between Adamsville and Chandlersville. It occupies smooth ridge crests, gentle lower slopes below ridges of Zanesville silt loam, and saddles between knobs and ridges of the Muskingum soils. In places it occupies benchlike positions suggestive of old terraces but offering no definite evidence that they are such. The soil is closely associated with the high-terrace phase of Holston silt loam and somewhat resembles the smooth phase of Muskingum silt loam, although the latter soil is more yellow and commonly contains more fragments of shale and sandstone throughout.

Zanesville silt loam, shallow phase, is well drained, and about 90 per cent of it is cleared and farmed. The remainder is associated with other soils and is in wood lots. It is generally regarded as being practically as good farm land as the typical soil and is farmed in the same manner and to the same kind of crops. Yields are about the same on the two soils, wheat averaging 20 or 30 bushels to the acre and corn 30 or 40 bushels in a good year.

FRANKSTOWN GRAVELLY SILT LOAM

The surface layer of Frankstown gravelly silt loam is gray or grayish-yellow silt loam containing an abundance of white, cream-colored, and black or somewhat reddish chert fragments. At a depth of 3 or 4 inches this passes into pale-yellow, very cherty silt loam which, at a depth of about 15 inches, grades into ocherous-yellow silty clay loam. At a depth ranging from 24 to 30 inches the unweathered parent cherty limestone is reached. This soil grades toward the Westmoreland soils east of Flint Ridge School, where limestone outcrops. Typically, the surface is so strewn with cherty fragments that it can not be penetrated with a soil auger, and the entire mass to the parent rock consists of probably one-fourth soil and three-fourths rock fragments. Along the margin between areas of this soil and of Muskingum silt loam, a few fragments are on the surface in patches. In places, outcrops or large boulders of the unweathered flinty limestone occur on the surface.

This soil occurs only on Flint Ridge and spurs extending from it. Its total extent is not large, but locally it is rather important. It occurs on rolling ridges and is very well drained throughout. About 60 per cent of it is cleared and farmed, the remainder being covered with a hardwood growth of oaks, chestnut, ash, and hickory. The soil is cultivated only with considerable difficulty. The chert fragments, when frequently stirred up, act as a mulch and prevent the loss of moisture. The presence of large quantities of chert and flint render this a comparatively early soil.

Corn and hay are the principal crops. Corn yields from 25 to 50 bushels to the acre, and mixed timothy and clover produces from 1½ to 2 tons to the acre. Clover does very well, especially near outcrops of cherty limestone. This is an excellent soil for apples, and several good orchards are on it. Peaches also do well. Superphosphate, the principal fertilizer, is used at the rate of 150 or 200 pounds to the acre.

MEIGS SILTY CLAY LOAM

Meigs silty clay loam is essentially a mixture of areas of the yellow Muskingum silt loam and red Upshur clay and Upshur silty clay loam, so intermingled as to be unmappable on the scale used. In places it consists of grayish-brown silt loam, 6 or 8 inches thick, underlain by yellow silty clay which grades into heavy plastic red clay at a depth ranging from 18 to 24 inches. Patches of red Upshur clay and Upshur silty clay loam are interspersed with areas of the yellow and grayish-brown soils, giving to plowed fields a patchy appearance. In places this is termed calico land. Several included areas, to a depth ranging from 18 to 24 inches, consist of rich-brown silt loam, characteristic of Zanesville silt loam. Below a depth of 24 inches the material is red plastic clay. In some places yellow soil has washed over red and in others red soil has washed over yellow.

Meigs silty clay loam is derived from interbedded red and gray shales and gray sandstone, and unweathered fragments of these rocks are on the surface and through the soil in many places. The unweathered parent rock occurs in most places at a depth ranging from 18 to 36 inches.

This soil occurs principally in the southern and southeastern parts of the county, the most important developments being in the vicinity of Freeland, north of Ruraldale, on the slopes above the headwaters of Meigs Creek, southeast of Coal Hill, and in the region between Brush Creek and Muskingum River. Smaller areas are in the central and eastern parts of the county. The soil occupies rolling or hilly areas and includes a few small, badly eroded areas. The slopes are subject to slumping, owing to the weakness of the red and gray shales, which give the soil a peculiar benchy and bumpy appearance. The relief insures thorough drainage, but erosion follows rapidly after clearing unless care is taken to keep the land in crops or grass. About 75 per cent of the soil is cleared, although only about 15 per cent of it is farmed. About 10 per cent of the cleared land is so steep or gullied as to be suitable only for forestry. This soil is commonly associated with the Westmoreland and Belmont soils, and most of it is used for grazing sheep and cattle.

Meigs silty clay loam is not a uniformly productive soil, as the patches of red soils produce better in wet seasons and the patches of yellow soils in dry seasons. Some corn and wheat are grown, yields being about the same as on Muskingum silt loam. The soil is acid, and most of the hay crop consists of redbud, whitetop, and other acid-loving vegetation. Fertilizers are not always applied to corn and wheat. Superphosphate is the most common fertilizer, and applications range from 100 to 175 pounds to the acre.

Lime is greatly needed by this soil and could be profitably applied with some superphosphate, especially to the permanent pastures. Care should be taken to stop incipient gullies, as this land is rapidly destroyed once gullies become established.

WESTMORELAND SILTY CLAY LOAM

Westmoreland silty clay loam is a mixture of Muskingum silt loam and Brooke silty clay loam, with many soil gradations between

the two. That part having the characteristics of the Muskingum soil consists of brown or yellowish-brown silty clay loam or silt loam grading, at a depth between 6 and 10 inches, into brownish-yellow heavy silty clay, underlain by shale and sandstone and in places by limestone at a depth ranging from 24 to 36 inches. The included Brooke clay or Brooke silty clay consists of dark-brown silty clay or clay grading, at a depth of 3 or 4 inches, into yellowish or brownish-yellow sticky clay, which in turn, at a depth of about 10 inches, passes into greenish-yellow, tough, sticky, plastic clay with some dark-brown mottles or splotches. Below a depth of about 18 inches there is tough, brownish and yellow clay, with some fragments of partly weathered limestone. In places the parent limestone occurs within about a foot of the surface, and it is everywhere found within 26 or 30 inches. On some of the slopes near the outcrop of the limestone the surface is closely strewn with limestone fragments. In addition to these small patches of limestone soils, the soil as a whole is subject to more or less wash from limestone formations on the ridge tops and slopes above. Areas north of Bridgeville are derived from Muskingum material and an impure limestone, and the resultant soil does not sustain so heavy a bluegrass sod as is found in the southeastern part of the county where the limestone is more pure and is present in greater abundance.

In Clay Township, about $1\frac{1}{2}$ miles northeast of Ebenezer School, on a ridge crest an included area is yellow or yellowish-brown silty clay loam with a yellow, sticky, plastic clay subsoil. It is associated with the Meigs soils, and a few patches of red clay show at the surface.

This soil occurs very extensively in the southeastern part of the county, extending south and southwest from New Concord toward Ruraldale and the Morgan County line. Other areas are north and south of Norwich and on Irish Ridge north of Frazeyburg, and small, widely scattered areas are mapped southeast of Frazeyburg, over the northeastern part of the county, and in the southern part of Clay Township.

Westmoreland silty clay loam occurs on narrow, rolling ridge tops and in uniformly rolling or steeply rolling and broken hilly country, where valleys are very narrow and V-shaped with but a ribbon of overflowed land, in many places too narrow to be shown on the map. Drainage is in most places well established, but the soil does not erode badly even on steep slopes, owing to the fact that much of it is seldom broken but is kept in bluegrass pasture. Slumps are of common occurrence, and in the displaced material there are usually small springy (seepy) spots that remain wet over long periods.

About 85 per cent of this soil is cleared, but only about 15 per cent of it is farmed, the remainder being grazed. It supports an excellent stand of bluegrass and can usually be readily distinguished from the Muskingum soils by the darker color of the grass cover. The timbered areas support a growth of oaks, hickory, chestnut, and some locust.

Corn and hay are the principal crops. Corn yields from 25 to 55 bushels to the acre and timothy and clover from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons of hay. Some wheat is grown, but it tends to winterkill on this soil. Clover, alfalfa, and sweetclover thrive.

Sheep raising is of especial importance on this soil, with its luxuriant growth of bluegrass and excellent springs and streams to supply water. The fine-wooled Delaine Merino sheep are raised, and this section is famous for the splendid quality of the wool clip. Many farmers devote themselves almost exclusively to sheep raising and hay production, and wool and lambs constitute the principal money crops of the section. Some apples are raised but not so many as formerly, owing to the difficulty of getting the crop to market over the uneven hilly roads. On many farms including some bottom land along with some of the Westmoreland soils, these soils are used exclusively for grazing and the bottom lands are devoted to the production of corn and hay.

The comparatively heavy texture of much of this kind of land makes somewhat heavier plows and equipment necessary. The land can be plowed in a narrower range of moisture conditions than the silty loam soils.

Applications ranging from 200 to 400 pounds of superphosphate to the acre every four or five years should be made to maintain this land in permanent pasture. The removal and burning or crushing of the limestone fragments from the surface and the application of the burned lime or ground limestone would be beneficial in obtaining a stand of alfalfa. The use of this type of soil for sheep and cattle pasture seems to be the most profitable utilization to which it can be put. If it were closer to market or roads were better, this land would be admirably suited to dairying.

Westmoreland silty clay loam, steep phase.—The basis on which the steep phase of Westmoreland silty clay loam is mapped is its relief; that is, the steepness of the slopes. It includes such areas as, owing to their unfavorable relief, are unsuitable for the crops common to this region. It may include a few patches that are being farmed in connection with a patch of bottom or some other soil, but it will be found that all such areas are cultivated only with considerable difficulty and by hand.

This soil is suitable for grazing and supports a good pasture growth. About one-third of it remains in woods, to which the steeper areas should be allowed to revert. This soil occurs principally in the southeastern part of the county, in association with the typical soil. It is most extensive from the vicinity of Norwich southeastward toward Zeno and High Hill.

BELMONT SILTY CLAY LOAM

Belmont silty clay loam represents an intermediate soil condition between the Meigs and Westmoreland soils or an association of these two soil conditions. Like them this soil is variable as to texture. In places red Upshur clay or Upshur silty clay loam predominates, and in others yellow areas similar to Muskingum silt loam make up most of the soil. Fragments of limestone, sandstone, and shales are present on the surface. The parent rocks outcrop in narrow bands and everywhere occur within 3 feet of the surface. The limestone and red shales commonly associated with this soil give rise to part of it.

Where the red shales are not present, the soils are mapped with Westmoreland silty clay loam. In other places, this soil seems to be derived in part from thick beds of sandstone. Even in such areas it is subject to wash from limestone soil above and has limestone fragments on the surface and in many places contains numerous lime nodules or concretions. In reaction the soil is neutral or slightly acid.

This soil occurs principally in Union, Rich Hill, and Meigs Townships, from the vicinity of Norwich and New Concord southward toward High Hill and Young Hickory. Other areas are mapped northwest and southwest of Bloomfield, southwest of Cedar Run, and south of Brush Run in Monroe Township. Typically the areas are hilly or rolling, and the slopes are marked by slumps and slides. Southeast of Spratt, west of Bloomfield, and near Brush Run included areas are smoother than typical, being comparable to Westmoreland silty clay loam.

This soil is well drained except in springy spots near slumps. Although steep, erosion is not generally severe. About 85 per cent of the soil is cleared of its hardwood growth and is used for sheep and cattle pasture. Only the smoother areas, comprising about 10 per cent of the total, are cultivated. Yields are comparable to those obtained on the Westmoreland soils. Corn produces from 30 to 60 bushels to the acre. Clover and alfalfa are grown successfully, although clover seems to run out after one year. Wheat yields from 13 to 18 bushels to the acre. As is true in the southeastern part of the county, the raising of fine-wooled sheep is the important agricultural activity on this soil which, as it supports an excellent bluegrass sod, is very well adapted to this use.

The farming methods and type of equipment used are the same as on Westmoreland silty clay loam. Superphosphate is the principal fertilizer, and the use of lime is common, as farmers have found that although slabs of limestone may be strewn on the surface the part dissolved from the rock leaches away rapidly and the soil may be acid.

This land has about the same selling price and range of adaptation as Westmoreland silty clay loam. It is a strong soil very well suited to alfalfa, hay, and corn, where the relief allows their culture. It is best suited to use as grazing land. From 200 to 400 pounds of superphosphate to the acre every 5 years and a ton of lime to the acre every 4 or 6 years greatly improve the quality and quantity of pasturage.

HANOVER SILT LOAM

In wooded areas, virgin Hanover silt loam has about a half-inch covering of leaf mold on the surface. This is underlain by a 2 or 3 inch layer of dark-brown or dark grayish-brown silt loam. Below this, to a depth of about 8 inches, is friable, grayish-brown silt loam. In cultivated areas the surface soil to a depth of 7 or 8 inches is grayish-brown or grayish-yellow friable silt loam. Between depths ranging from about 8 to 24 inches is brownish-yellow silt loam, having a rather granular structure. This material becomes slightly more compact with depth and passes, at a depth of about 24 inches, into compact, heavy silt loam or silty clay loam of yellowish-brown

color and rather coarsely granular structure. Some fine yellowish-gray material present in places along fracture planes imparts a slightly mottled effect. Below a depth of 28 or 30 inches is brown or olive-brown, compact heavy silt loam or light silty clay loam which does not show so high a degree of compaction as the material just above. Below a depth ranging from 40 to 48 inches is the more or less unweathered glacial material, which typically consists of slightly mottled brown, olive-brown, grayish-brown, or rust-brown heavy silt loam. Rounded pebbles and rock fragments are common in this layer, and in places these occur in small numbers in the overlying layers. Boulders and cobbles are rare but are present in a few places.

In places mapped areas of this soil include patches in which the lower part of the subsoil shows some stratification, indicating that it is of water rather than ice deposition. Here and there stratified and unstratified materials are intimately associated. The stratified deposits consist of silt, clay, sand, and gravel, but the laminated silty deposits are probably predominant. These materials weather to give a soil very similar to that derived from the associated unsorted glacial drift. In a road cut near the west county line, the underlying material is light silt loam containing some very fine sand from 36 to 70 inches below the surface. Below a depth of 70 inches is a pale-yellow silt loam layer showing definite lamination and carrying a few pebbles in the lower part. This, at a depth of about 86 inches, grades into partly weathered till consisting of silty clay loam mottled brown, pale yellow, yellowish gray, and rust brown and containing numerous rounded sandstone pebbles and some of crystalline origin. Such areas are of such minor extent and importance that it is impractical to show them separately.

Hanover silt loam is of very small extent. It occurs only in the western part of the county, chiefly south of Gratiot in Hopewell Township. The edge of the glacier which is believed to have crossed the county for a short distance² extended from the county line about 3 miles north of Gratiot, south along the eastern side of Kent Run, thence southeast to Wesley, and from there southwest to the county line. The boundaries of the glacial area are not very definite and within the glaciated area evidences of ice-laid material are not everywhere prominent. Only within the valleys are the deposits sufficiently distinct to be readily differentiated from the residual deposits. In fact, the soils on the uplands are in most respects similar to Muskingum silt loam and have been included with that soil where separation could not be made on clearly shown differences in the soil profile. Locally very small deposits of glacial drift occurring within the unglaciated area because of their limited extent have not been separated from Muskingum silt loam. The chief areas of Hanover silt loam occur on the west side of Kent Run, north and south of Gratiot, near Wesley and to the southwest near the county line.

This soil occupies gently rolling areas and in places a part of it has a subdued knob-and-sag relief characteristic of a morainic surface. Surface drainage is good, and underdrainage is fairly well

² STOUT, W. GEOLOGY OF MUSKINGUM COUNTY. Geol. Survey Ohio, Ser. 4, Bul. 21, 351 pp., illus. 1918.

established. Only on the more level areas and in depressions is the underdrainage imperfect.

In productivity and agricultural value Hanover silt loam is very similar to the smooth phase of Muskingum silt loam, and similar crops are grown. General farming is followed on this soil. Wheat yields 18 or 20 bushels to the acre and corn about 40 or 50 bushels. Soybeans are grown. Superphosphate is the most commonly used fertilizer. This soil is generally acid, hence liming is desirable for clovers and is very essential for alfalfa or sweetclover. Some tiling may be desirable in the more level areas. Practically all of the soil is cleared, and its favorable relief has resulted in most of it being cultivated.

WHEELING FINE SANDY LOAM

Wheeling fine sandy loam is rich-brown medium or fine sandy loam from 5 to 8 inches thick, underlain by yellowish-brown, compact sandy loam containing some gravel. Below a depth of 16 or 18 inches is yellowish-brown, fairly open loamy fine sand or fine sandy loam, not compacted as is the layer above. Below a depth ranging from 30 to 36 inches is the underlying glacial gravel and sand substratum. Here and there some gravel may be seen on the surface.

South of Blackrun on a low divide, the light-brown very fine sandy loam or fine sandy loam surface soil passes, at a depth of about 6 inches, into yellow or yellowish-brown fine sandy loam underlain by compact brownish-yellow fine sandy loam, beneath which is yellowish-brown loamy fine sand. There is considerable variation in this soil, owing to its somewhat billowy surface. Here and there are hummocks, swells, or low ridges of lighter texture than typical, and intervening small swales or flats having somewhat heavier surface soils of heavy sandy loam or silt loam. This condition is especially prominent near Duncan Falls. South of Trinway the soil contains some loamy fine sand. In the area south of Blackrun, the surface is marked by several sinks resembling glacial depressions. These are, however, thought to have been the result of surface washing. Above Gilbert a limestone formation crops out at the surface in spots, the soil is shallow, and some fragments of limestone are scattered over the surface.

This soil occurs as terraces or second bottoms along Muskingum and Licking Rivers and some of their tributaries, which have all received drainage waters from the glacial region to the north and west. Practically none of it is subject to regular overflow, although some of the lower areas were flooded in 1913. The most important areas of this soil occur at Trinway, Dresden, Gilbert, Ellis, south of Drake, near Zanesville, Brighton, South Zanesville, and on most of the river terrace on the east side of the river from Zanesville to Duncan Falls. Other areas occur near Adams Mills, along Jonathan and Moxahala Creeks near Moxahala Park, south of Blackrun, and 2 miles up Big Run from Licking River. Small areas occur at other places along these streams. A number of gravel pits and banks have been opened in this soil.

Typically Wheeling fine sandy loam occupies level or gently sloping or undulating areas, but much of it is marked by low ridges and

swales. It is uniformly well drained, owing to its comparative openness and the porosity of the substratum.

This soil is one of the most important trucking soils in the county. All of it is cleared, and all except what is utilized as sites for towns and farmhouses is farmed. Trinway, Dresden, much of the terrace part of Zanesville, and part of Brighton, Putnam, South Zanesville, and Duncan Falls are located on this soil.

Truck crops, including tomatoes, potatoes, sweet corn, asparagus, cucumbers, celery, watermelons, cantaloupes, eggplant, and peppers are grown. The sandiness of the soil insures good drainage and easy tillage and makes the soil warm up early in the spring. Several poultry farms are located on this soil, because of its excellent drainage. Corn, wheat, oats, and clover are also grown, as are also some sweetclover and alfalfa.

Plowing and tillage operations are comparatively easy on this soil, and its flat surface is favorable to the use of up-to-date machinery. For the general crops, superphosphate is the usual fertilizer, applied at the rate of 200 or 300 pounds to the acre, but with the truck crops and melons a variety of mixed fertilizers is used. Two common mixed fertilizers analyze 0-10-10 and 3-12-2, respectively. With too many growers the price of the fertilizer rather than the contents seems to be the basis of purchase.

Applications of manure range from about 6 to 10 tons or more to the acre but vary with the quantity available and the kinds of cover crops grown. The soil is slightly acid or neutral, and some lime is used for clover and alfalfa. Sweetclover grows well along banks where the underlying gravel is exposed. Rotations are not definitely planned as a rule, but crops are changed about from patch to patch to control insects and diseases.

Land of this kind, situated as it is in valleys well above overflow, has a considerable value as building sites as well as for farm land. There are a number of fine country homes on it.

The following rotation is generally recommended by the Ohio College of Agriculture as being suitable for this soil in this locality: First year, cabbage and peas, followed by a cover crop of sweetclover or sweetclover and vetch; second year, melons, cucumbers, eggplant, peppers, or beans, followed by cover crops of rye or rye and vetch; third year, early potatoes or sweet corn, followed by a cover crop of crimson clover; and fourth year, tomatoes, followed by a cover crop of soybeans or cowpeas (sown at the last cultivation). An application of 1 or 2 tons of ground limestone to the acre is advised for each rotation, depending on the lime requirement of the soil. An application of fertilizer, varying with the crop and quantity of manure available, should generally be made also. In general, a fertilizer containing about 4 per cent nitrogen, 12 per cent phosphoric acid, and from 4 to 6 per cent potash is recommended for truck crops. The soil requires a large supply of organic matter for best results, and the growing of cover crops is very necessary where insufficient manure is available. The openness of the soil and frequent cultivation tend to burn out the organic matter more rapidly than in heavier soils.

WHEELING LOAM

The surface soil of Wheeling loam is brown or dark-brown loam grading, at a depth of about 7 inches, into yellowish-brown loam. At a depth of about 15 inches this layer passes into yellowish-brown fine sandy loam and shows little change to a depth of 36 or 40 inches. Below 40 inches stratification is distinct and the material is variable, consisting of yellowish light loam and fine sandy loam. At a depth of 45 or 50 inches gravel and sand are present. Some gravel may be found on the surface and through the subsoil. Included with the soil in places are small patches of silt loam and fine sandy loam.

This soil is mapped in fairly large areas west of Zanesville near the county infirmary, and at Philo, Merriam, and Stone along Muskingum River. Other areas occur along Kent Run and along Jonathan and Moxahala Creeks between Fultonham and South Zanesville, along Muskingum River above the mouth of Symmes Creek, in the big valley in the upper part of the county just north of the old canal basin, and in widely scattered areas along the two rivers and the creeks leading from the glacial section to the north and west.

Wheeling loam occupies level or undulating terraces along the river and main streams in the western part of the county. Drainage is excellent throughout and, owing to the gravelly texture of the substratum, may be somewhat excessive and produce a droughty condition.

All of this soil is cleared and, with the exception of areas included in town and building sites, is all farmed. Some of it is devoted to truck crops and berries, but the general crops of corn, wheat, and grass are the most important. Corn yields from 25 to 40 bushels, wheat from 12 to 20 bushels, and hay $1\frac{1}{2}$ or 2 tons to the acre.

Fertilizers are extensively used, superphosphate being most widely used on general crops and complete fertilizers on the truck crops. Wheeling loam is especially in need of organic matter, and the application of manure and the growing of cover crops are especially necessary for truck crops. The soil is normally slightly acid, and from 1 to 2 tons to the acre of lime every three or four years is recommended for it. A rotation like that suggested for Wheeling fine sandy loam is also suitable for Wheeling loam.

WHEELING SILT LOAM

Wheeling silt loam is brown silt loam to a depth of 6 or 8 inches, passing into light-brown or brownish-yellow, heavy, somewhat compact silt loam or silty clay loam containing a few small gravel. Below a depth of 24 or 26 inches is brownish-yellow gritty loam or coarse sandy loam containing considerable gravel, and below a depth ranging from 36 to 40 inches is brownish-yellow sand mixed with gravel. Below about 50 inches are beds of glacial gravel and sand. Near the cement plant at Fultonham Station the subsoil below a depth of about 3 feet consists of compact, slick, gray, water-laid clay. The soil as mapped includes small areas of loam and, in depressions or swales, of silty clay loam.

This soil occurs extensively south of Blackrun, near Nashport and Irville, 2 miles southwest of Nashport, and near Adams Mills,

Trinway, and Dresden. Other areas are mapped near Ellis, in Putnam, near Parkinson School, at Fultonham Station, along Big Run, and scattered along the Licking and Muskingum River terraces. The soil occupies level or very gently undulating areas and is uniformly well drained. Sweetclover grows luxuriantly along banks of the out-cropping gravel substratum.

Like the other Wheeling soils, this soil is the site of several villages and many farmhouses and buildings. It is entirely cleared and farmed. Corn, wheat, oats, alfalfa, and hay are the principal crops, but truck crops are of considerable importance near Nashport. Corn yields from 30 to 60 bushels, wheat from 12 to 25 bushels, oats from 25 to 40 bushels, and hay from $1\frac{1}{2}$ to 4 tons to the acre. Alfalfa does very well when the soil is limed. Some rye is grown.

Superphosphate is in general use and some mixed fertilizers are used on truck and berry crops. The soil is limed for alfalfa and clover and to some extent for wheat. The use of lime is recommended for general crops, including clover, and liming is essential for alfalfa. Fertilizers analyzing about 4-12-4 or 4-10-6 are suggested for truck crops.

HOLSTON SILT LOAM

The surface soil of Holston silt loam is grayish-brown, light-brown, or grayish-yellow silt loam which grades downward, at a depth of 5 or 7 inches, into brownish-yellow or yellowish-brown, heavy, somewhat compact silt loam. At a depth of about 15 inches yellowish-brown or brownish-yellow compact silty clay loam or heavy silt loam is reached. Below a depth of 35 or 36 inches yellow or brownish-yellow friable silt loam, splotted with light gray and rust brown, occurs. This is much less compact than the layer above. Just east of Brush Creek, the soil has a somewhat bumpy relief, is somewhat variable in structure, and a few scattered pebbles are observed on the surface. Also, a stiff, plastic slack-water clay is present within 3 feet of the surface.

In places this soil includes rather large quantities of shale chips and small sandstone fragments or gravel washed down from slopes above. In the smaller areas along streams flowing through uplands of Muskingum soils this soil is distinctly more yellow than typical in the larger areas. The substratum locally consists of unweathered shale and sandstone formations, stratified sands and clays, in places admixed with some gravel, derived mainly from sandstone and local upland rocks.

This soil occurs on second bottoms or terraces along the tributary streams and is derived by wash from the sandstone and shale soils of the surrounding uplands. It is rather extensive in the northern part of the county near Frazeyburg, north and northeast of Otterbein School, along Salt Creek near Smith Mill and on down to Pierce, along Boggs Creek, along Moxahala Creek below Moxahala Park, and along Joes Run, Bartlett Run, and Big Run. Other areas occur near Blackrun, along Wills Creek west of Marquand Mill, scattered along White Eyes Creek, near Sonora on Little Salt Creek, west of Zanesville along Timber Run, near Fultonham, and along Brush Creek and Manns Fork Salt Creek. Other areas of less importance are mapped along the smaller streams throughout the county.

Holston silt loam occupies level or gently undulating areas. It is all cleared and farmed. Most of it lies above overflow, and it is utilized in many places for farmhouse sites. Drainage is generally good, except where the soil is associated with the Monongahela or Tyler soils.

This is an important agricultural soil and in some of the hilly sections this land, together with the associated bottom soils, comprises the tillable land on some farms. It is used for the general crops, corn, wheat, and hay, and a few areas are devoted to potatoes, strawberries, and truck. Dairying is carried on particularly near Zanesville and along the main roads.

Corn yields from 25 to 60 bushels to the acre, wheat from 12 to 25 bushels, and hay $1\frac{1}{2}$ or 2 tons. The relief is favorable to the use of tractors and up-to-date farm tools, and a number of modern homes are found on this kind of land. Some of it is tile drained to aid the escape of excess moisture which is sometimes impeded by the compact subsoil. The use of fertilizers is practically universal, superphosphate being applied on the wheat and usually on the corn at rates of 250 and 150 pounds to the acre, respectively. Lime is in general use where it is available or the haul from railroads is not too long.

Holston silt loam is typically acid, and applications of lime are essential to the growth of clover. Alfalfa can be grown after applying lime and superphosphate. Tile drainage would be beneficial over practically all of the soil, although shallow water furrows would aid in carrying off excess surface water. This soil is very well adapted to the production of wheat, corn, hay, potatoes, tomatoes, and strawberries.

Holston silt loam, high-terrace phase.—The high-terrace phase of Holston silt loam is typically light-brown silt loam, from 4 to 6 inches thick, passing down into rich-brown silt loam, which, in turn, at a depth of 15 inches, grades into somewhat compact brown silt loam or silty clay loam. At a depth between 20 and 24 inches this passes into noncompact brown silt loam which continues with little change to 34 or 36 inches where there is in most places a slightly grayish mottling. Below a depth of 40 or 50 inches is the substratum, which consists of more or less definitely stratified very fine sandy loam, silt, and clay with some severely weathered sandstone fragments.

East of Zanesville water-laid gravel of glacial origin occurs in a pit under this soil, and in the same vicinity molding-sand pits have been opened. On top of the hill to the northeast of South Zanesville, sandstone and shale rubble, such as is seen in creek beds, is exposed in a molding-sand pit. West of Rock Cut some widely scattered quartz gravel may be seen. In places the material is somewhat more yellowish than typical.

North of Moxahala Park some patches of Monongahela silt loam are included. As compared with the typical soil, the high-terrace phase is generally browner, possibly owing to its higher elevation, greater age, and hence longer exposure to oxidation. It very closely resembles Zanesville silt loam, the main difference being the mode of occurrence and the presence of gravel and stratified materials in the substratum, as may be seen in road cuts south of Stringtown.

This soil occurs on high stream benches and rather flat shoulders or saddle positions in the sites of old valleys at elevations between 800 and 860 feet above sea level. It is extensive around the head of Joes Run, west of Township Hall, west of Ellis, in the vicinity of Robertson School, near Oakland, east of Zanesville, west and south of Carlwick, west of Bridgeville, west and south of Sonora, north of Griffin, south and east of Chandlersville, in the old valley between Moxahala Park and South Zanesville, and up the west side of the valley of Moxahala Creek toward Roseville. Smaller areas are mapped in the central part of the county.

This soil is very important agriculturally, and all of it is cleared and farmed. Its adaptation and uses are similar to those of typical Holston silt loam. North of Moxahala Park it is extensively used for strawberries, and it is generally considered one of the best wheat soils in the county, closely approaching Zanesville silt loam for this purpose. It is typically acid or slightly acid, and lime is generally applied, especially for wheat, clover, and alfalfa. Wheat averages higher in yields than on Holston silt loam.

HOLSTON LOAM

The surface soil of Holston loam consists of dark grayish-brown, grayish-yellow, or yellow loam 6 or 8 inches thick, grading into light-brown fairly compact loam. At a depth of about 15 inches this passes into yellowish or light-brown, rather compact silt loam which continues to a depth of about 28 inches, where it grades into brownish-yellow loam or very fine sandy loam, showing some gray and rust-brown splotches. Included patches are more sandy than typical, approaching the texture of fine sandy loam or very fine sandy loam. On the east side of Moxahala Creek 2 miles north of Ironspot two included patches consist of light-brown fine or medium loamy sand. Fragments of sandstone and shale and sandstone pebbles may be present in the surface soil and subsoil.

This soil occurs on terraces of streams which flow principally through uplands of sandstone and shale soils. It is not extensive but is mapped along Joes and Bartlett Runs west and northwest of Zanesville, in the vicinity of Frazeyburg and east along Wakatomika Creek, about $1\frac{1}{2}$ miles southeast of Shannon, about 1 mile northwest of Duncan Falls between the river terraces and Indian Run, near Smith Mill, and in patches along Salt Creek north of Lawton and one-half mile south of Parkinson School.

Areas of this soil are flat, undulating, or hummocky. Its sandy texture and openness make it an easily handled, tractable soil. It is fairly early in the spring and is well drained. All of the soil is farmed, mainly to general crops, although locally, near Zanesville, patches are used for truck crops and melons. The soil is farmed in much the same manner as the adjacent Holston and Monongahela soils. Superphosphate and lime are commonly used.

Holston loam is well suited to truck. It is acid or slightly acid and is well adapted to potatoes, tomatoes, and strawberries. For general crops, particularly for clover, lime is essential. The soil is in general poor in organic matter and increased yields can be obtained through growing cover crops and legumes and applying manure.

MONONGAHELA SILT LOAM

The surface soil of Monongahela silt loam consists of grayish-brown silt loam streaked with gray and rust-brown stains. This grades, at a depth of about 8 inches, into yellow, compact heavy silt loam or silty clay loam mottled with rust brown. Below a depth of 15 inches is yellow, compact silty clay loam mottled with light gray and rust brown. This grades, at a depth of 22 or 24 inches, into mottled ochreous-yellow, rust-brown, and light-gray silt loam less compact than the layer above. The gray color becomes more conspicuous with depth. The substratum consists of stratified material, in most places heavy clay, which in places has layers of sand or loam below. Small, rust-brown iron concretions are common in the surface soil and subsoil.

Patches of Tyler silt loam too small for separation are included in mapping. Between Irville and Shannon on the east side of the old valley are several included patches of Monongahela loam. North of Moxahala Park this soil is mapped in connection with Holston silt loam, high-terrace phase, but would have been separately mapped had it been more extensive.

This soil occurs in old stream valleys, on stream benches or terraces, and for the most part lies above normal overflow. It is extensive south of Blackrun and between Blackrun and Frazeyburg and eastward. Other areas occur north of Trinway, near Shannon, northeast of Irville, west and northwest of Township Hall, west of Stringtown, north of Walker School, along Wakatomika Creek near Crawford Bridge, along White Eyes Creek near Otsego, north and southwest of Robertson School, along Buffalo Creek near Chandlersville, and in numerous small patches along Salt Creek. Areas are flat or gently undulating, but the drainage is not perfectly developed, owing to the compactness of the subsoil and clay substratum. A part of the soil has been tile drained, but surface ditches are most commonly used to drain it. It is about 95 per cent cleared and farmed, the timbered areas supporting a growth of elms, beech, ash, some hickory, and various oaks and some sycamore.

The crops common to the county are grown, and a large part of the soil is devoted to the production of hay. It produces fairly good crops of corn, wheat, and potatoes, and supports a good cover of grass. It produces from 30 to 50 bushels of corn, from 12 to 18 bushels of wheat, and 1 or 2 tons of hay to the acre. Near Moxahala Park it is used to some extent for strawberries. Superphosphate is used on the wheat and on many farms on the corn. Lime is used extensively. Methods of farming are similar to those used on the Holston soils, and the relief is favorable to the use of tractors and modern farm equipment.

In the improvement of this soil, lime is of the utmost importance. About 1 or 1½ tons of limestone to the acre every four years would correct the acidity. Internal drainage is essential, owing to the structure and the character of the substratum, and tile drainage would prove very beneficial. With drainage and lime, clover can be successfully grown and the humus supply built up. Potatoes, tomatoes, and strawberries produce well on this soil.

TYLER SILT LOAM

Tyler silt loam is gray or dark-gray silt loam mottled with rust brown to a depth of 6 or 7 inches, where it grades into mottled light-gray, ocherous-yellow, and rust-brown silty clay loam which is compact but not plastic. At a depth of about 24 inches less compact material is found, and below a depth of about 30 inches is mottled yellow and gray very smooth silt loam. Below a depth ranging from 30 to 36 inches there are alternate layers of clays, silts, gritty clays, and sands. In places, sand layers occur at a depth of 26 or 30 inches, and a few gravel or fragments of sandstone and shale may be found through the soil. The substratum at a depth of 40 or 50 inches is in many places neutral or alkaline in reaction, although the surface soil is very acid. In most places small dark-brown or black iron concretions are numerous.

Southeast of Shannon and near Blackrun, in swales or low places, patches of silty clay loam are included with this soil in mapping, owing to their small extent. Included also are several areas, such as the one 2 miles southeast of Shannon where lime experiments have been conducted, that have a mottled yellow and gray surface soil with a mottled gray and rust-brown silty clay subsoil. These areas lie a little higher than the average and are somewhat better drained.

This soil is most extensive near Blackrun and between Frazeyburg and Trinway, south of Nashport, in the old valleys near Shannon and west of Stringtown, at the head of Bartlett Run, east of Vandenberg School, and at the north edge of the terrace section of Zanesville. Small, widely scattered areas are mapped on the terraces through the central and western parts of the county. The soil occupies old abandoned valleys, benches, and terraces where the materials have been washed principally from sandstone and shale soils of the uplands. It is associated with the Monongahela and Blago soils.

Tyler silt loam occupies flat or slightly undulating areas, and drainage is poor owing to the surface features, the compact consistence, and the presence in the substratum of layers of clay which prevent the ready movement of soil water.

This is not an important agricultural soil. About 70 per cent of it is cleared and about one-third of it is farmed, the rest being grazed. The timbered areas support a growth of shagbark and smooth-bark hickory, oaks, walnut, beech, elm, and ash trees. The typical vegetation in unfarmed fields consists largely of sedges, sorrel, bulrushes, ironweed, and smartweed.

The farmed areas are devoted to corn, wheat, and hay. All the farmed land is drained by shallow surface ditches or tile. Until about 25 years ago the section around Blackrun was a swamp and was little used except for grazing. Since being drained it has been practically all farmed. Corn yields from 25 to 35 bushels to the acre and wheat from 10 to 15 bushels. Hay averages between 1 and 1½ tons to the acre.

This soil is late and difficult to handle, owing to its wet, poorly drained condition and its compactness and close structure. Wheat frequently winterkills. It is common practice to plow this soil in narrow lands and leave the dead furrows between for surface-water drains. Superphosphate is used on wheat, and some lime is applied

by most farmers. Good stands of red clover have been obtained on some of the better-drained areas by the use of lime. Where kept in pasture for several years, the quality of the grazing rapidly deteriorates and the acid-loving rushes, sorrel, and other weeds crowd out the grass and white clover unless the land is limed and fertilized.

In improving this land, drainage must be the first consideration. Tile drainage, though expensive, has been found profitable. The soil is extremely acid and poor in organic matter. This condition can be remedied by the use of lime and superphosphate, which will enable the clovers to get started. The application of 2 or 3 tons of limestone to the acre would neutralize the acidity sufficiently to allow the growth of red clover and 1 or 2 tons every four years would maintain the soil in this condition.

BLAGO SILTY CLAY

Blago silty clay has a characteristic black appearance in the field when moist but assumes a dark-gray color on drying. It breaks up into small cubes or pellets and has what is termed a buckshot structure. Below a depth of about 8 inches is dark-gray or almost black, tough, plastic clay which, at a depth of about 15 inches, grades into light-gray, tough, waxy, plastic clay mottled with ocherous yellow and rust brown. This material continues with little change to a depth ranging from 36 to 40 inches, where it passes into brownish-gray or mottled gray and yellow, tough, plastic clay, which is neutral or in places alkaline in reaction, in contrast to the acid surface and upper subsoil layers. In some places it is black or dark gray to a depth of 18 or 20 inches and grades into heavy, waxy, bluish-gray clay at a depth ranging from about 20 to 24 inches. This grades into mottled gray and yellow gritty clay. About 2 miles southwest of Shannon and about one-half mile southwest of Irville patches of muck too small to be shown separately are included in mapped areas of this soil. In dry weather this soil cracks and shrinks badly, and crops suffer unless they are cultivated frequently. As the soil is moistened it swells and the cracks close.

This soil occurs in old valleys in association with the Tyler and Monongahela soils, occupying depressions or low-lying areas within areas of those soils. It is very patchy in occurrence, and some of it was mapped with Tyler silt loam near Blackrun, where the areas were too small to be separated. It is extensive near Shannon, along the new Coshocton road near Township Hall, around the head of Bartlett Run, in the abandoned valley running northwest from Nashport, along the old Dresden road north of Walker School, and near Blackrun. Small areas occur in the old abandoned valley in the northwest part of the county and on the east side of Muskingum River about 1 mile below Dresden.

Areas are flat or slightly depressed, and drainage is poor. Locally this is an important soil. Practically all of it is cleared and most of it is in cultivation. It is especially favorable to corn, and this crop yields from 50 to 100 bushels to the acre in a good year. Oats yield from 25 to 60 bushels, wheat from 15 to 25 bushels, and hay from 2 to 4 tons to the acre.

Blago silty clay is very difficult to plow and cultivate and requires heavy plows, tools, and work animals. If it is worked when too dry

or too wet it becomes cloddy and is then extremely hard to cultivate. It produces best in a moderately wet year, because during dry seasons it dries out and cracks, and the crops are apt to suffer. In cornfields where this soil occurs in patches, the corn in early summer is darker green and larger than on associated soils. Very excellent timothy, redbud, alsike, and red-clover hay is produced. Two crops are frequently cut in one season. Superphosphate and lime are used extensively.

Blago silty clay probably contains more plant food than any other soil in Muskingum County. It will withstand hard cropping. The application of lime at the rate of 1 ton to the acre every four years will benefit this land by rendering it more easily cultivated and will bring the soil to a reaction suited to the growth of clovers.

HUNTINGTON SILT LOAM

Huntington silt loam is dark rich-brown or brown, mellow silt loam with very little difference in color or texture to a depth of 3 or more feet. In places it includes small patches of loam or very fine sandy loam, particularly near stream banks and on low hummocks, and some patches of silty clay loam. In other places the subsoil is variable in texture, ranging from silty clay loam to loamy sand or sand. Some gravel is on the soil or in the subsoil.

This soil occurs in stream bottoms and is subject to overflow. It is best developed along Licking and Muskingum Rivers, Wakatomika, Salt, and Moxahala Creeks, and some of the larger tributary streams in the eastern part of the county. It is usually thought of as a soil developed from alluvial deposits along streams which receive a large part of their wash from upland soils of limestone or mixed limestone and shale origin. The waters of the main streams of the county are alkaline or hard, and the soils developed from their depositions are likewise alkaline or only very slightly acid.

Areas of this soil are flat, marked here and there by low hummocks and old stream channels. Drainage is excellent throughout. This is one of the most important bottom-land soils in the county, owing to its extent and productivity. Practically all of it is cleared and farmed, but narrow fringes of sycamore, willow, poplar, ash, and maple are left along the river banks to protect areas from washing. In the hilly sections this soil is in many places utilized for the production of corn and grain, and the hill fields are used for pasture.

Corn and hay are the principal crops, corn occupying about two-thirds of the cultivated area. Alfalfa and clover are grown to some extent and do well, owing to the favorable reaction of the soil (neutral or slightly acid). Corn yields from 40 to more than 100 bushels to the acre and hay from 2 to 4 tons, with two cuttings in some seasons. Wheat and oats do well but may suffer from overflow or from lodging about the time they ripen. The soil is very well adapted to alfalfa. One large field of sweetclover was seen south of Adams Mills.

It is a general practice to put this land in corn for two or more years and then seed it to grass or sow wheat, followed by grass. The soil is readily plowed and cultivated, and its relief is favorable

to the use of tractors and modern equipment. No fertilizers are used. Many farmers pull the ears of corn and then pasture cattle on the standing stalks and plow the residue under the next spring. Most farmers on this kind of land have their homes built on terraces beyond the effect of flood waters. The soil is subject to fresh additions of alluvium almost annually but is also sometimes affected by washing or depositions of gravel and sand during floods.

Huntington silt loam is seldom sold except in connection with other soils, whose value it enhances.

Huntington silt loam, high-bottom phase.—The high-bottom phase of Huntington silt loam is separated from the typical soil on the basis of its elevation and comparative freedom from overflow. Its area corresponds practically to that part of the county which lies above the ordinary low bottoms but which was covered by the 1913 flood. It is practically identical with typical Huntington silt loam, except that the surface soil is not so rich brown in color but is rather yellowish brown. The soil is not normally so alkaline in reaction as the typical soil.

This soil is mapped most extensively in the Muskingum River bottoms east of Trinway. Other areas are west of Trinway and scattered in the high bottoms of Muskingum River southward along its course. Several areas are along Licking River, just west of Zanesville.

The high-bottom phase of Huntington silt loam is used for the production of corn, wheat, and hay, as well as for some trucking in connection with the Wheeling soils south of Zanesville. Methods of farming are in the main similar to those employed on the typical soil. However, some superphosphate is applied for wheat, and a few farmers use some lime.

Corn yields slightly less than on the low-bottom soils, but wheat and oats give higher average yields and are more extensively grown. Alfalfa and red clover are grown extensively.

Its high productivity, favorable relief, and freedom from any except very exceptional floods make this one of the most desirable soils in the county.

HUNTINGTON SILTY CLAY LOAM

Huntington silty clay loam is dark-brown or chocolate-brown silty clay loam which becomes somewhat lighter colored in the subsoil. It is rather variable in texture, ranging from silty clay to very fine sandy loam. It may include small patches of Huntington silt loam, and in a few low places, swales, or old drainage ways where drainage has been impeded, it is somewhat mottled with gray and rust brown. Such areas would be mapped as Holly silty clay loam were they more extensive.

Huntington silty clay loam occurs in the lowest parts of the bottoms, commonly next to a terrace or hill slope where in times of high water the current is slowest, allowing the settling out of the finer particles carried in suspension. This is not an extensive soil, occurring chiefly east and northeast of Trinway and in long narrow bands or strips on the bottoms above and below Rock Cut on both sides of Muskingum River. About 95 per cent of it is cleared.

The remainder, consisting principally of sloughs and old stream courses, is timbered with sycamore, elm, willow, poplar, and cottonwood.

This soil is devoted to the production of corn and hay. Many farmers have kept it in corn continuously for many years without any decrease in yields. Corn yields from 60 to more than 100 bushels to the acre. Hay consists mainly of mixed timothy and clover, and yields range from 2 to 3 tons to the acre. Alfalfa succeeds very well on this soil, and a number of patches yield from 2½ to 4 tons annually. Sweetclover and horseweed grow luxuriantly in uncultivated areas. As the soil is subject to almost annual overflow the supply of plant food is regularly replenished, and no fertilizers of any kind are used. This soil is neutral or alkaline in reaction.

HUNTINGTON FINE SANDY LOAM

Huntington fine sandy loam, to a depth of 10 or 12 inches, is rich-brown fine sandy loam or loamy fine sand. This grades into rich-brown loam or fine sandy loam underlain, at a depth ranging from 36 to 40 inches, by brownish-yellow sand. In much of the soil there is practically no color change and but little change in texture from the surface to a depth of more than 3 feet.

Included with this soil in mapping are patches of very fine sandy loam, loam, and loamy sand, and in several bends of Licking River above Dillon patches of river wash consisting of yellowish-brown sand piled in hummocks and overgrown with sycamore, alders, and willows and strewn with debris brought in during flood times are included. In the bottoms on the east side of Muskingum River north of Gilbert the relief is ridgy or hummocky with old stream ways or sloughs between the ridges. The texture is rather variable, ranging from fine sandy loam to silt loam. Some patches are very gravelly.

This soil occurs in the overflow bottoms of Muskingum and Licking Rivers and some of their larger tributaries. It is extensive along Muskingum River from east of Adams Mills to Dresden, on Licking River throughout its course in the county, on Jonathan and lower Moxahala Creeks, on Wakatomika Creek, and in scattered areas along some of the streams in the eastern and central parts of the county. About 95 per cent of the soil is cleared and farmed, mostly to corn and hay. The methods used are similar to those employed on Huntington silt loam. Much of the corn is not cut, the ears being husked and gathered directly into wagons and the stalks grazed and turned under the next year. It is usually good practice to gather the corn as soon as possible to avoid loss from an unexpected rise in the river. Corn yields from 60 to 100 bushels to the acre. The hay crops are mixed red clover and timothy, and alfalfa, and yields range from 2 to 4 tons to the acre. The 1925 crop of hay was excellent on this and other bottom soils, although it was poor on the terrace and upland soils on account of an unseasonably dry June. Some soybeans are grown.

This soil could, to some extent, be used for trucking, as it warms up rather early.

Huntington fine sandy loam, high-bottom phase.—The high-bottom phase of Huntington fine sandy loam has approximately the same color and structure as the typical soil, but in most places the surface soil is slightly more yellowish and there is not so much variation in texture. The high-bottom phase occurs on the higher areas of the bottoms of Muskingum and Licking Rivers, but it is overflowed only by such unusual floods as the one of 1913.

Areas of this soil are flat, gently sloping, gently undulating, ridgy, or hummocky. The soil occupies the high bottom between Trinway and Adams Mills and narrow disconnected strips down Muskingum Valley and on Licking River between Dillon and Zanesville. It is not extensive but is entirely cleared. Between Zanesville and Duncan Falls it is used, in conjunction with the Wheeling soils, for the production of truck crops. In other sections it is devoted to corn, hay, and grasses. Some of it is used for home sites, and much of Zanesville is built on it because it is above normal overflow. Near Trinway wheat averages between 15 and 20 bushels to the acre, but yields of 30 bushels are reported; corn yields from 60 to 100 bushels, averaging about 75 bushels. Some rye and oats are grown. Hay produces $2\frac{1}{2}$ or 3 tons to the acre. Below Zanesville in the trucking section this soil is devoted to asparagus, melons, sweet corn, tomatoes, potatoes, and other truck crops. Rye, alfalfa, and sweetclover are seeded in the truck patches for hay and cover crops.

Farming methods are similar to those employed on the other Huntington soils and on the Wheeling soils. Superphosphate is used with the general crops, and some lime has been applied by a few farmers. High-grade complete fertilizers are applied on the truck crops and melons.

MOSHANNON SILT LOAM

The surface soil of Moshannon silt loam is dark-brown silt loam having a reddish cast when moist. This passes, at a depth of about 6 inches, into reddish-brown silty clay loam containing numerous shale fragments and becoming somewhat redder with depth. This soil is derived from wash from the Meigs, Upshur, Westmoreland, and Muskingum soils and owes its color to the red Upshur material. As seen in the field in exposures it has a distinctly reddish color, but when examined it appears more brownish than red.

Patches of Moshannon silty clay loam and Moshannon silty clay are included in mapping, as are also small patches of colluvial material of a bright Indian-red shade.

This soil occurs only along some of the streams in the southeastern part of the county. The largest areas are along Meigs Creek and its tributaries, at the head of Buffalo Fork south of Freeland, at the head of Kent Run west of High Hill, and at the heads of streams between Rix Mills and New Concord.

All of this soil is cleared and about 75 per cent of it is farmed to corn and grain. The remainder is in pasture. Yields of corn average between 50 and 60 bushels to the acre. Oats, wheat, and hay are grown to some extent. Where the soil occurs in bottoms too narrow or too badly cut up by the stream meanders to be efficiently cultivated, it is utilized for pasture, as it supports a very fine

growth of bluegrass and clovers. Since it is subject to almost annual overflow no fertilizers are applied. It is a strong soil, neutral or very slightly acid in reaction, and is best suited to the production of corn and grass.

POPE FINE SANDY LOAM

The surface soil of Pope fine sandy loam is brown or dark-brown fine sandy loam passing down, at a depth of 6 or 8 inches, into lighter-brown fine sandy loam or loam in which there is little color or textural change to a depth of 3 or more feet. In places below a depth of about 30 inches there is a little gray mottling. As mapped, the soil includes small patches of silt loam.

This is a first-bottom soil, occurring along streams which drain sandstone and shale uplands. It is very inextensive, occurring principally along Kent Run north of Fultonham and in scattered areas along Salt Creek below Bridgeville. It is well drained and is all cleared. It closely resembles Huntington fine sandy loam, but is typically acid in reaction and less productive. Corn and hay are the principal crops grown. Corn yields from 25 to 60 bushels to the acre. About one-third of the soil is used for pasture. It supports a growth of redtop, some bluegrass, white clover, and alsike.

This soil is farmed in the same way as Huntington fine sandy loam. No fertilizer, manure, or lime is applied as the soil is subject to frequent overflows, at which time additional deposits of alluvium are made. Corn is grown successively for several years and then is followed by hay for several years. Alfalfa can be grown if the land is limed.

PHILO SILT LOAM

Philo silt loam consists of brown, light-brown, or grayish-brown silt loam, underlain at a depth of 10 or 12 inches by yellowish-brown silt loam which passes, at a depth of about 18 inches, into mottled brown, gray, and rust-brown silt loam. In places the mottles are seen at a depth of 10 or 12 inches. Included in mapped areas of this soil are patches of light-brown, brown, or grayish-brown loam, especially near areas of Muskingum loam in the uplands. Patches of the Atkins soils, too small to separate, are also included.

This is a first-bottom soil and is found along streams in sandstone and shale regions. A few areas, mapped in close association with Huntington silt loam and probably representing Lindside silt loam, are imperfectly drained. The surface is flat. In some of the small valleys the soil is too cut up by meandering streams and old channel ways to be used for anything but pasture. This soil occupies an intermediate place between the Pope and Atkins soils.

Philo silt loam occurs along Big, Bartlett, Timber, Thompson, and Kent Runs, Buckeye Fork, Brush, Symmes, Bluerock, and White Eyes Creeks, along the upper course of Salt Creek, and on Boggs and Duncan Runs and some of their tributaries. Drainage is fairly good. About 90 per cent of the soil is cleared and farmed or used for pasture. The remainder supports a growth of dogwood, black walnut, locust, hickory, maple, willow, sycamore, elm, and beech. In the pastures is a growth of buffalo grass, orchard grass, and some bluegrass, white clover, and alsike, as well as numerous

sedges, rushes, and other acid-land vegetation seen on imperfectly drained soils.

Corn and hay are the principal crops, although some wheat is grown. Corn yields from 25 to 40 bushels and hay from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons to the acre. Wheat yields from 12 to 20 bushels. Some superphosphate is used on the corn, at the rate of about 200 pounds to the acre, and a 2-12-2 mixed fertilizer, at the rate of 200 pounds to the acre, is applied for wheat.

Philo silt loam is very well suited to the production of corn and grass and to use as pasture land. Tile drainage, application of lime, and top-dressing with superphosphate would greatly increase its productiveness and the quality of the hay and pasturage.

ATKINS SILT LOAM

The surface layer of Atkins silt loam is mottled grayish-brown, dark-gray, and rust-brown silt loam which gradually becomes heavier and more grayish with depth, until at a depth of about 24 inches it passes into dark-gray and rust-brown silty clay loam which extends without much change to a depth of more than 3 feet. Small areas of Atkins silty clay loam are included with mapped areas of this soil in sloughs and low places. In some of the smaller stream valleys small patches of Philo silt loam are also included. Where Atkins silt loam is mapped in association with the Huntington soils wet areas of Holly silt loam are included.

This soil occurs along most of the secondary streams in the county, particularly those receiving most of their drainage from sandstone and shale uplands. It occurs particularly in small springy bottoms at the headwaters and on the small tributaries of some of the large creeks and in poorly drained back edges and depressions in the better-drained bottoms. Areas of this soil occur in the bottoms of Wakatomika Creek east of Frazeyburg, along Mill Creek, Stump and Joes Runs, at the heads of streams west and south of Gratiot, and along Moxahala, Brush, Symmes, and White Eyes Creeks. It is uniformly very poorly drained and is readily distinguished by the growth of ironweed, rushes, alders, and *Spiraea* which it supports.

This soil is practically all cleared and about two-thirds of it is farmed to hay and corn. The remainder is in pasture. The yields of hay crops are fairly heavy, but the quality is usually low owing to the inferior quality of the grasses and weeds which this soil naturally supports. Corn yields from 20 to 35 bushels to the acre.

In improving Atkins silt loam, drainage is the first essential, followed by applications of lime and some superphosphate. With this treatment, better yields of corn and higher-quality hay and pasturage will be obtained.

ROUGH STONY LAND

Rough stony land consists of very steep, eroded or stony land, with rocky cliffs and hillsides made rough by slumping. Such land is totally unsuitable for agricultural use, with the exception of the little grazing it affords. This class of land includes a few areas where the erosion on slopes has gone on unchecked, so that the land

is now worthless for farming purposes and in places resembles bad lands. Rough stony land is best suited to forestry and should be maintained in forest.

Areas of this kind of land occur principally on the steep hills along Muskingum River south of Gilbert, south of Sealover, east of Philo, near Bluerock Creek and Cedar Run, along the branches of Bluerock Creek, north and southeast of Blackrun, and in several areas along Big Run southeast of Pleasant Valley and north of Yelptown School. Small areas are widely scattered over the county.

MINE PITS AND MINE DUMPS

In this classification are included molding-sand pits, gravel pits, rock quarries, and clay pits, and the land which has been dug over in the coal-stripping operations. Areas of this kind occur in most of the hills in the vicinity of Zanesville, although many of them are too small to be shown. Areas are shown south of Dresden, near Gilbert, east of Kelley Store, in the vicinity of Robertson School, northeast of Brookover, and in the vicinity of the brickyards at Fultonham Station, Ironspot, and Roseville. This land has no agricultural value.

AGRICULTURE

The agriculture of Muskingum County dates back to about 1800. The early settlers grew corn and some small grains and raised some cattle and sheep and a few hogs, principally for home use. Theirs was a self-sufficient type of farming, and the food and most of the needed clothing were produced at home. The few other articles needed were obtained by exchange of grain, hides, wool, and similar products. Garden truck for home use was raised by all settlers, and game abounded in the woods. Zanesville was early established as a manufacturing town, owing to the water power available from Muskingum and Licking Rivers. Clay manufacturing, coal mining, and lumbering became important, and the demand for food and agricultural products sprang up. The now abandoned canal from Lake Erie to Ohio River crossed the upper part of the county and made cheap transportation available to this section. The river, United States Highway No. 40, and the railroads all furnished outlets for manufactured products and excess agricultural products. Fruit raising reached its greatest importance about 1900. Trucking, poultry raising, and dairying became important, especially near Zanesville. Much of the hill section of the county was cleared and farmed to general crops, but difficulty in working such land resulted in much of it being used for pasture land or turned back to forest, and the patches of bottom land or smooth ridge tops were devoted to crops. Sheep and cattle raising gradually became important.

At present agriculture over most of the county is of the general type in which corn, wheat, oats, and hay are the main crops, hogs and cattle are raised for home needs, some sheep are raised for wool and lambs, and surplus livestock products are the source of most of the cash income. However, through the southwestern part of the county, particularly in sections where limestone soils are extensive, sheep raising is the major agricultural enterprise. Fine-

wooled Delaine Merino sheep for wool production are favored, although a number of farmers are crossing fine-wooled ewes with mutton-type rams. The lambs are sold and only enough fine-wooled rams are kept to maintain the fine-wool strain. This is part of a fine-wool sheep section which ranks among the best in the country. Between Meigs Creek and Young Hickory a number of purebred Angus and Hereford cattle are raised.

The present tendency in the hilly region is toward grazing and away from even as much cropping as is now done. Here the stream bottoms are depended on for the production of corn and grain, but here and there a field of one of these crops or of hay is seen on the smoother parts of the uplands. Sheep and cattle raising are also important in the northern part of the county. On the sandy soils along Muskingum and Licking Rivers truck crops, small fruits, and melons are very extensively produced and in the vicinity of Zanesville are several dairies, poultry farms, and orchards.

Cereals occupy the greater part of the cultivated land and are the most valuable class of crops grown. According to the 1920 census, corn in 1919 was grown on 32,413 acres. The average yield was 42 bushels to the acre. This comparatively high average is owing to the fact that corn is grown largely on the more fertile bottom lands where yields ranging from 60 to 100 bushels to the acre are often reported.

Wheat was second in importance in 1919, being grown on 31,854 acres with an average yield of 19.8 bushels to the acre. The present tendency is to decrease the acreage of wheat, owing to the unfavorable winters the last two years and to the low price obtained for this grain. In 1919 oats were raised on 7,413 acres and gave a total production of 168,266 bushels. Rye was grown on 516 acres and produced 6,655 bushels. The value of all cereal crops for 1919 was \$3,537,831.

Hay and forage crops rank next in importance, both in acreage and value. In 1919, 52,300 acres were devoted to all tame and cultivated grasses, producing 57,846 tons of hay. Of this total, 31,750 acres were in timothy alone, 17,663 acres were in timothy and clover mixed, 1,823 acres were in clover alone, and 924 acres were in alfalfa. The value of the hay and forage was \$1,890,622. The silage crops consisted mainly of corn.

The value of all livestock in 1920 was \$3,358,749, of dairy products in 1919 was \$899,661, and of wool in 1919 was \$439,603. Receipts from the sale of chickens and eggs were \$478,034. Egg and poultry buyers run trucks through the county, and several milk and cream trucks collect dairy products along the better roads.

The value of vegetables in 1919 was \$447,437. Vegetables consist of tomatoes, beans, peas, sweet corn, peppers, asparagus, cabbage, potatoes, and sweetpotatoes. The 1920 census reports 1,047 acres in potatoes and 465 acres in other vegetables in 1919. Some of the vegetables, particularly the tomatoes, are sold through a cooperative marketing organization. They are raised principally on the sandy and silty terraces of Muskingum and Licking Rivers. Watermelons, cantaloupes, and strawberries are grown in connection with the vegetables. Strawberries are also grown on a number of small patches of Muskingum loam and Muskingum silt loam in the western part

of the county and in the old valley north of Moxahala Park, a total of 63 acres being reported for this crop in 1919. Raspberries were grown on 37 acres in 1919, in various parts of the county. In the southern part of the county west of the river, raspberries do very well on the Muskingum and Zanesville soils. These crops formerly occupied a very much larger acreage, according to the census.

In 1919 there were in the county 114,816 apple trees, 58,883 peach trees, 10,616 pear trees, 12,440 cherry trees, and 8,703 plum trees of bearing age. Fruit raising was once an important industry in the county, as is shown by the census reports. Little care was given the trees, and diseases soon killed a large number. Few plantings have been made in recent years, and at present there are few commercial orchards in the county.

The soils and relief have had a strong influence on the crops and types of farming in the county. As has been mentioned, the farmers in the hilly sections, having found that cultivating the hills was unprofitable, have turned to sheep and cattle raising with considerable success; the farmers on the sandy, loamy, and silty terraces (Wheeling soils) have found these areas especially adapted to the production of truck, melons, and small fruits; farmers on the other terraces and on Zanesville silt loam recognize the especial adaptation of these soils to wheat; the limestone lands are recognized as best suited to the production of clovers and alfalfa and to grazing; the chert lands on Flint Ridge (Frankstown gravelly silt loam) are well adapted to apples; and the overflowed flood plains are devoted almost entirely to corn and hay.

The equipment on the average farm includes 2-horse plows and tillage tools, hay-making machinery consisting of mowers and dump rakes, wagons, and other necessary implements. In the hilly sections small patches of grain are sometimes cradled, where binders are not available. The work animals are of average size and are used by many farmers both as work animals and for drawing buggies and wagons. The houses and other buildings are comfortable and adequate, and the houses are generally painted and well kept. In the smooth valley sections the equipment includes up-to-date tillage tools and plows, binders, side-delivery rakes, hay loaders, manure spreaders, grain and lime drills, and on many farms tractors and tractor-drawn implements. The work animals are of medium or heavy draft types. The houses and barns are large, and many are equipped with running water and lights. Silos are common. A few farmers cooperatively own silage cutters, threshing machines, and hay balers.

The crop rotation used in the general-farming section is corn, wheat, and clover and timothy. The hay is left on the fields for 2 or 3 years. Occasionally oats are grown in this rotation. In the trucking sections where little manure is available, cover crops of vetch, rye, sweetclover, and soybeans are sometimes grown for turning under. The truck crops are seldom grown on the same land for more than 2 successive years, as a protection against diseases and insects and to avoid injury to the land. Some farmers pasture their hay lands for a year or two after cutting hay for 2 years. In the bottoms subject to overflow, corn is grown for 2 or 3 years and is then followed by hay, wheat, or oats. If alfalfa or clovers catch

well, they are allowed to remain for 2 or more years. The alfalfa sometimes persists for 4 or 6 years before it entirely runs out.

In 1919, 2,546 farmers reported the use of fertilizers, the expenditure for this purpose amounting to \$161,772, or \$63.54 a farm. Superphosphate is the most commonly used fertilizer in most parts of the county, but the truck and berry growers use mixed fertilizers of various analyses but commonly high in phosphoric acid and some form of potash, with a lower percentage of nitrogen. Some farmers apply no nitrogen in the commercial form but grow legumes to accumulate this more expensive element. Available manure is applied on the cornland and grassland. Lime is used widely, and its use is increasing. It is generally applied with the wheat or hay crops. Some farmers haul a load of baled straw to town and sell it for more than enough to pay for a load of lime, which they haul back to the farm. There is a good demand for straw at the box-board plant in Dresden. The potteries also use this material in packing their various wares and products.

The employment of labor was reported on 1,433 farms in 1919, and this item of farm expense totaled \$341,352 for the county. The labor is principally white and American-born and is usually scarce, owing to the larger wages paid at the mines, mills, and factories. School children from Zanesville are often employed to pick strawberries. The truck growers need much more extra help than the general farmers.

The purchase of feed was reported by 2,467 farmers in 1919, at a cost of \$357,198.

The 1920 census reports 3,688 farms in Muskingum County. The average size of the farms is 106.3 acres, of which 87.9 acres are improved land. The farms vary considerably in extent. In the grazing section they comprise from about 100 to 400 acres, whereas in the trucking section they range in size from a few acres to 60 or 80 acres. Farms including from 160 to 400 acres are common in the bottoms near Trinway and Nashport and on the terraces near Frazeysburg. The present tendency is to increase the size of the farms.

In 1920, 81.9 per cent of the farms were operated by the owners, 17 per cent by tenants, and 1.1 per cent by managers. The usual method of renting land is on the share basis, the owner furnishing the land, fertilizer, and all or part of the seed, and the renter supplying labor, work animals, and usually part of the farm tools.

According to the census of 1920, the average value of farm land in the county was \$37.99 an acre. Over much of the hilly, broken country prices range from about \$8 or \$10 an acre to about \$30, but in the better farming sections prices range from \$50 to \$200 an acre. The truck lands near Zanesville are valued at prices ranging from \$600 to more than \$1,000 an acre. The presence of coal, molding sand, and clays affects the prices of land.

In the hilly sections of the county there has been a very decided drift away from agriculture, and abandoned farmhouses are numerous. In such places the fields are thrown together and the entire farm is used for pasture. The buildings and fences rapidly deteriorate, and various bushes, young trees, and briars encroach on the fields and decrease their value for pasture. Many formerly cleared fields have reverted to woods. The comparatively low fertility and

steep slope of a large percentage of the hilly land of the county naturally inhibit development for agriculture, and the reversion of such lands to forest or grazing land appears inevitable under present economic conditions. Erosion, both by gullying and by sheet washing or surface skimming, is going on at a comparatively rapid rate throughout this part of the county and is hastening the depletion of the soil and plant-food supply and subsequent farm abandonment. No hillside terraces have been built, and contour plowing to control erosion is uncommon. The use of such control methods, the growing of cover crops during winter, and the utilization of the steeper slopes as pasture and forest lands are suggested as means for conserving such lands.

The ridges, particularly those near the river valleys and including the Frankstown, Zanesville, Westmoreland, and Muskingum soils, offer possibilities for fruit raising. The Frankstown soils are particularly suited to apples. The wider development of dairying, particularly where good pasture is afforded, as on the Westmoreland soil, and the extension of poultry raising seem to offer excellent possibilities, in view of the increasing demands for these products.

SOILS (TECHNICAL DISCUSSION)

The soils of Muskingum County are typically light colored, having developed in a region of humid-temperate climate under a forest cover, which does not tend to promote the accumulation of organic matter as does a grass cover. Blago silty clay, which has a black surface soil, is an exception. It was developed in low, poorly drained, marshy areas in the terraces and has accumulated, under these conditions, a good supply of dark-colored organic matter in the upper part. No free carbonates are present, all of these having been leached out in the soil-forming processes. Fragments of limestone may be present, but in producing soil all the lime carbonate has been removed.

Throughout the uplands of Muskingum County the soils have been formed from the sandstones, shales, and limestones of the region through the processes of rock decay and subsequent soil development. The soils for the most part are in the early stages of development, since erosion removes the soil material from the steeper areas approximately as fast as it is formed.

The coarser sandstones give rise to loams and spots of sandy loams; very fine-grained sandstone and arenaceous shales produce silt loams; and the clay shales and limestones form clays and silty clay loams. The soil-forming processes, which effect greatest changes in the material formed through decomposition and disintegration of the rock materials, operate best in areas of smooth relief where these materials may be undisturbed over long periods of time and thus receive the full effects of such agencies as leaching and soil transposition. The hilly relief of most of the county has not been favorable to these processes but has promoted rapid denudation of the products of rock decay, preventing their accumulation in sufficient quantities over sufficiently long periods to allow the soil to approach maturity by receiving the full impress of the climate. By the term "maturity," in speaking of soils, is meant that condition brought

about through a long period of exposure, in a smooth area, of the parent materials to the soil-forming activities of the climate (oxidation, leaching, and transposition) and other natural agencies, such as vegetation, in which there is developed a series of definite soil characteristics independent of those of the parent materials. A mature soil shows a complete profile, which in this region consists usually of a topsoil of one or more layers, which may include a thin surface film of humus or decayed vegetable matter and a thoroughly leached layer, typically light in texture; a subsoil in which the materials removed from the topsoil tend to accumulate and which is commonly heavier and more compact than the topsoil; and the substratum which consists of the unweathered or partly weathered parent material. These horizons may be further subdivided, depending on color, texture, and structure.

Zanesville silt loam and Tilsit silt loam have most nearly the characteristic profiles of mature soils of the humid, timbered region, according to the conception previously stated. Zanesville silt loam, in a wooded area 2 miles east of Zanesville, has the following profile: (1) To a depth of 5 inches, a thin film of decaying vegetable matter underlain by a thin layer of grayish-brown silt loam, beneath which is dark-brown silt loam. This layer breaks up into small particles of no definite form and is easily crushed. (2) Between depths of 5 and 10 inches, easily crushed brown silt loam of a floury or deflocculated structure. (3) Between depths of 10 and 29 inches, reddish-brown or dark-brown silt loam grading at a depth of 14 inches into light silty clay loam. The upper part of the layer crushes easily, but below a depth of 14 inches the material is fairly compact and contains the fine material brought down from above. The color lines are not sharp, the inside of the particles being brown and the outside slightly lighter brown. The upper part of the layer has a deflocculated structure; between depths of 14 and 20 inches about half the material is in recognizable particles, the clods breaking along the fracture line of the particles; and between depths of 20 and 29 inches the particles are from one-fourth to one-half inch in diameter, clods break around the particles, and most of the material is in recognizable particles. (4) Between depths of 29 and 51 inches, brown or buff fairly easily crushed silt loam grading, at a depth of 37 inches, into loam or fine sandy loam which becomes more sandy with depth, with gray and dark brown through the particles. The gray is brought out, giving a streaked appearance, when a small fragment is rubbed between the thumb and finger. The gray and rust-brown shades increase with depth, but at a depth of about 50 inches the material appears dark brown, owing to the presence of iron concretions. The upper part of the layer breaks into particles about one-fourth inch along the longest axis, clods breaking both across and around the particles. Below a depth of 37 inches, clods break across the particles. (5) Between depths of 51 and 70 inches, fairly compact gray fine sandy loam through which, when moist, there are yellowish streaks. Brown splotches present seem to be materials from above or incipient iron concretions. A broken surface shows numerous black and brown iron concretions, and along some of the cracks and veins may be seen a thin film of very light gray or almost white. Some brown tubes of material occurring in

this layer appear to be insect tube casts filled with material from higher layers. The layer is of flattish platy structure which varies considerably.

Tilsit silt loam on Flint Ridge in the western part of the county shows the following profile: (1) To a depth of 10 inches brown or grayish-brown easily crushed silt loam showing no definite arrangement into particles. The color seems to sift down along cracks, old wormholes, roots, and root casts. (2) Between depths of 10 and 20 inches, yellow or brownish-yellow easily crushed silt loam grading, at a depth of 14 inches, into more compact light silty clay loam. The inside of the particles is somewhat more brownish than the outside, and cut surfaces appear more pronouncedly yellow than broken surfaces. To a depth of 14 inches the structure is somewhat platy; below that depth large aggregates are made up of smaller particles which separate rather easily. Clods break around the particles, and about three-fourths of the mass consists of recognizable particles. (3) Between depths of 20 and 35 inches, yellowish-brown, brown, and light-gray rather compact light silty clay loam grading, at a depth of 29 inches, into very compact, somewhat porous silty clay loam containing streaks of clay, in which the clods break across rather than around the particles. The particles are from one-fourth to three-fourths inch in size, are irregular in shape, and appear to be cemented together by iron oxide. The outside of the particles usually is somewhat paler than the inside, owing to the presence of a thin film of lighter material. (4) Between depths of 35 and 72 inches, compact somewhat porous silty clay loam with streaks of clay, grading at a depth of 42 inches into more easily crushed silt loam in which the compaction seems to result mostly from the iron oxides present. The inside of the particles is slate gray, brown, and pale yellow, without definite arrangement, the colors grading into each other. Cut surfaces show a grayish-brown or brown face with smears of dark-brown concretionary material. Along the cracks are accumulations of gray clay varying from a film to about one-fourth inch across. This material is of very fine texture. In the lower part of this horizon this gray material is lighter colored and approaches very fine sandy loam in texture. To a depth of 42 inches, the structure is the same as of the overlying material; below that depth, clods break across and around the particles, which are from one-fourth to three-eighths inch along the longest axis, are irregular in shape, and are smoother on the outside than on a broken surface. (5) Between depths of 72 and 75 inches, very compact and hard yellowish-gray and dark-brown silt loam cemented with iron. The ground color is light yellow, veined with gray and dark brown. Iron concretions are numerous and range up to about one-eighth inch in diameter. In a cut surface, these smear into reddish streaks, as compared with the dark brown in the overlying horizons. The gray material in the larger cracks in this horizon shows a neutral or alkaline reaction to soiltext. This material is difficult to crush, owing to the cementing effect of the iron oxide present, and crumbles into powder. (6) Between depths of 75 and 95 inches, pale-yellow silt loam or light silty clay loam, more or less cemented but much less compact than the overlying material. Along the cracks is a thin film of dull-brown material, and some small dark-brown iron accumulations and thin

veins of dark-gray material are present. The particles seem to be cemented together and break across rather than around. (7) Between depths of 95 and 108 inches, hard, compact silty clay loam similar to that in the 72 to 75 inch layer. This material is cemented with iron.

All the other upland soils have developed under conditions of good or excessive drainage and aeration, but their profiles are predominantly immature and show an imperfectly developed topsoil, no subsoil, and a substratum. In fact, these soils consist mostly of parent material or substratum. On the slopes the removal of the weathered surface layer by erosion and addition through wash and creep from above alter the soil material from time to time and prevent the development of a true soil.

The recently deposited alluvial soils along the streams are young when considered as to the development of a profile. They have no such sectionized profiles as the soils of the flat areas described above, as they are the product of recently deposited materials washed out of the upland soils. The Meigs and Belmont soils impart a reddish color to the well-drained bottoms near by, the other upland soils giving brownish or yellowish bottom lands. In the poorly drained areas primary colors have been altered to gray, bluish, and rust brown, as the result of deoxidation.

The terraces or high bottoms consist of old alluvial material no longer subject to overflow. These soils occupy smooth, level benches and have tended to develop distinct horizons in the same manner as has taken place in the uplands. In fact the true difference between terrace and bottom soils is this development of a well-zonated or sectionized profile in the terrace soils.

The terrace soils are of two distinct groups, depending on their origin: Those derived from the near-by uplands, including members of the Holston, Monongahela, and Tyler series, and the Wheeling soils deposited by waters coming from the melting glacier to the north.

SUMMARY

Muskingum County is in the east-central part of Ohio and comprises an area of 664 square miles. It is marked by many physiographic features, chief of which is an old abandoned valley across the northern part and numerous old abandoned valleys in the central and northwest-central parts. The surface is hilly in the northern, eastern, and southern parts, with steep slopes and narrow valleys and ridges; hilly or rolling with wide smooth ridges, gentle slopes, and wider valleys in the central and western parts; and level or gently rolling in the old valleys and along the stream bottoms and terraces. Elevations range from 660 feet above sea level where Muskingum River leaves the county to 1,280 feet at High Hill in the southeastern part. The county as a whole is well drained.

The population in 1920 was 57,980, and the average density of the rural population was 42.8 to the square mile. There is a gradual drift from the farm, and numerous abandoned farms are seen in the hilly sections. Zanesville, the county seat and largest town, had a population of 29,569 in 1920.

Transportation facilities are adequate, and the main roads are very good.

The climate is characterized by long, warm summers and moderately cold winters with sufficient rainfall for the needs of the crops grown.

Agriculture is, for the most part, of the general type with corn, wheat, and hay the important crops. In the southeastern part of the county, in the section of the limestone soils, sheep raising is very important. Fine-wooled Delaine Merino sheep, the principal breed, are raised for the wool. Along the river terraces below Zanesville trucking is very important. Dairying and poultry raising are important near Zanesville.

A wide variety of soils is found in Muskingum County. The Zanesville, Tilsit, and Hanover soils are examples of mature upland soils of this region. The Zanesville soils are extensive and are especially suited to wheat. The Hanover soils are of glacial origin. The Muskingum soils, derived from sandstone and shales, are the most extensive in the county. The Frankstown soils are extremely cherty or gravelly and occur only on Flint Ridge. They are very good soils for apples. The Meigs, Westmoreland, and Belmont soils occur principally in the eastern and southeastern parts and constitute the best grazing soils of the county. The Meigs are mixed red and yellow soils; the Westmoreland are similar to the Muskingum but are subject to limestone wash; and the Belmont are mixed yellow and red soils subject to limestone wash.

The Wheeling terrace soils are glacial-outwash material. They constitute the best truck soils in the county.

The Holston, Monongahela, and Tyler soils occur in the old abandoned valleys and on terraces or high bottoms. They are derived principally from sandstone and shale uplands. The Holston soils are well drained, the Tyler poorly drained, and the Monongahela are intermediate between them. The Blago soils are black or dark gray and occur in low areas or depressions in the Tyler and Monongahela soils. These terrace soils are used for general farming and grazing.

The bottoms include the Huntington soils, which are very good, well-drained soils derived in part from wash from mixed limestone, shale, and sandstone soils and especially suited to corn and hay, including clover and alfalfa; the Pope soils, resembling the Huntington, but derived mainly from sandstone and shale and less productive than the Huntington; the Atkins soils, which include the poorly drained equivalents of the Pope soils and are best suited to grass and corn; the Philo soils, intermediate between the Pope and Atkins in drainage and productivity; and the Moshannon soils, which include reddish bottom lands, which receive considerable wash from the Meigs and Belmont soils and which are productive corn and hay soils.

Rough stony land and mine pits and mine dumps are miscellaneous classifications of nonagricultural land.

Muskingum County offers real opportunity for specialized farming. The Frankstown soils and many of the Muskingum and Zanesville ridge soils are well adapted to fruit raising which, as roads are excellent, shipping facilities good, and markets within

reasonable distance, should be a profitable line of agricultural endeavor. Sheep and cattle raising on the limestone soils offer excellent opportunities to stockmen. Trucking could be made much more important through a closer organization of the truckers for the purpose of grading and disposing of their products. Much of the rough, hilly parts of the county should be set to permanent forests. Over a period of years this would prove a profitable investment.

Lime is generally needed on the soils of the county and its use is recommended for the general crops and many of the truck crops. Phosphorus is the element of plant food, after nitrogen, most needed by the soils of the county. It can probably be best applied in the form of superphosphate, and the nitrogen can be supplied through growing clovers and legumes. Dairying offers excellent opportunities. Very great improvements in the permanent pastures can be brought about by the intelligent use of lime and superphosphate. Such improvements, as figures from demonstrations conducted in southeastern Ohio show, can be made at a reasonable cost and are highly profitable when the increased quality and quantity of the pasturage, which make possible the grazing of greater numbers of sheep and cattle, are considered.



[PUBLIC RESOLUTION—No. 9]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Area surveyed in Ohio, shown by shading

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LEGEND

Arkine silt loam A ₁	Muskingum loam M
Belmont silty clay loam B ₁	Muskingum silt loam M ₁
Blago silty clay B ₂	Smooth phase M ₂
Franktown gravely silt loam F ₁	Steep phase M ₃
Hanover silt loam H ₁	Philo silt loam P ₁
Holston loam H ₂	Pope fine sandy loam P ₂
Holston silt loam H ₃	Thist silt loam T ₁
High terrace phase H ₄	Tyler silt loam T ₂
Huntington fine sandy loam H ₅	Westonland silty clay loam W ₁
High bottom phase H ₆	Steep phase W ₂
Huntington silt loam H ₇	Wheeling fine sandy loam W ₃
High bottom phase H ₈	Wheeling loam W ₄
Huntington silty clay loam H ₉	Wheeling silt loam W ₅
Mingo silty clay loam M ₁₀	Zanesville silt loam Z ₁
Monongahela silt loam M ₁₁	Shallow phase Z ₂
Mushannon silt loam M ₁₂	Rough stony land R ₁
	Mine pits and mud dumps X

CONVENTIONAL
SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwaters, Levers, Lighthouses, Forts.	Railroads, Steam and Electric
Secondary roads and trails	Elevations, Tunnels
Bridges, Ferry	School or Church, Courthouse
Ford, Dam	Bluff, Escarpment, Rock outcrop and Transgression station
Mine or Quarry, Mine dumps, Mud lands	Soil boundaries
Swamp and Gravelly areas	Boundary lines
Boundary lines	U.S. township and section lines
Boundary lines	

RELIEF
(Printed in brown or black)

Contours, Depression contours	Prominent hills, Mountain peaks
Sand washes and sand dunes	Shore and low water line, Sandbar

DRAINAGE
(Printed in blue)

Streams	Lakes, Ponds, Intermittent lakes
Intermittent streams	Swamps, Canals and ditches, Flumes
Swamp, Salt marshes	Submerged marsh, Tidal flats

The above signs are to
be used on the soil
map as shown in the
shape of the letter.